Part 1

AIR PROTECTION FROM POWER INDUSTRY EMISSIONS

1.3. Sulfur oxide emission reduction

1.3.2. Technologies of sulfur oxide emission reduction

1.3.2.10. Application of Venturi scrubbers

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Application of Venturi scrubbers for sulfur dioxide collection is based on washing of flue gases with soda solution accompanied by conversion of the reaction product in calcium sulfate. The main chemical reactions of the technology are the following:

$$2NaOH + SO_2 = Na_2SO_3 + H_2O;$$
$$Na_2CO_3 + SO_2 = Na_2SO_3 + CO_2;$$
$$Na_2SO_3 + Ca(OH)_2 + 2H_2O + {}^1/_2O_2 = CaSO_4 \cdot 2H_2O + 2NaOH.$$

Desulfurization plant (Fig. 1.45) consists of the following: Venturi scrubber *1*; converter *2*; separator of solid and liquid phases *3*; reservoir of liquid reagent *4*. The installation operates as follows. Into Venturi pipe-coagulator soda solution is injected, which simultaneously removes sulfur dioxide and fly ash from flue gases. In the centrifugal gas collector liquid is separated from gases, which flows down as a slurry and is then supplied to the converter. Purified gases are heated as necessary to prevent condensation of moisture on the surfaces of gas flues and fettling of a chimney and are emitted into atmosphere. The slurry after entering the converter is mixed with the limestone suspension, as a result of which natrium sulphate is converted into calcium sulfate. Then, in the separator of the solid and liquid phases, calcium sulfite is oxidized up to double water sulfate. After that natrium hydroxide solution enters the reservoir *4* and returns for Venturi scrubber irrigation, and the solid phase - a mixture of ash with the double water gypsum, is dumped to the ash disposal site.

Since the scrubber is irrigated with the sodium carbonate solution, hence formation of difficult-to-remove gypsum deposits is eliminated. Discharge of the slurry, containing gypsum, at the ash disposals, contributes in sealing of the ash disposal bed and reduction of filtration water supply, enriched with heavy metals, into natural water basins.

It should be noted that this technology with relevant changes is applicable when using other wet ash collectors, in particular, emulsifiers. Technical and economic indicators of this desulfurization technology are presented in Tab. 1.22.

For boilers of lower capacity, desulphurization with application of scrubbers can be realized with intensive irrigation regime (IIR) and ash leaching. Its indicators are given in Tab. 1.23.

This technology practically without changes can be also applied for other types of scrubbers, in particular, for emulsifiers, started to be applied at some TPPs as highly efficient ash collectors. But in this case because of deep cooling of flue gases, up to the temperature of water dew point, heating by 20 ... 25 ° C is required to prevent corrosion of the further gas channel and the chimney torch.

Characteristics of dual alkaline desulfurization with scrubber (Venturi) application for boilers of lower capacity are given in Tab. 1.24.

Table 1.22. **Indicators of desulfurization technology of TPPs flue gases with use of Venturi scrubbers**

Achievable desulfurization efficiency, %	50
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…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 reagent	Soda, lime
Reagent toxicity	Lime is toxic
Reagent excess factor	1,1...1,15
Resulting waste	Pulp, containing ash, calcium sulphate and a little bit of natrium sulphate
Necessity of the purified gases heating	It is needed heating of gases in 20…25 °C
Influence of desulfurization on ash collector operation	Emission of fly ash is reduced in 2 ... 3 times
Specific area for equipment installation, m^2/kW	Less than 0,001
Specific energy consumption, % of equivalent unit (boiler) capacity	Less than 0,3
Specific capital costs, U.S. $/kW of the installed capacity	9,9…15,5 for n' = 0,6…1,0 g/MJ and N_e = 80…200 MW
Specific operating costs, U.S. cents/(kW·h)	0,48…4,0 for n' = 0,6…1,0 g/MJ and N_e = 80…200 MW
SO_2 collecting costs, U.S. $/t	242…740 for n' = 0,6…1,0 g/MJ and N_e = 80…200 MW

Table 1.23. **Indicators of desulfurization in Venturi scrubbers with ash leaching**

Indicator	Steam-production capacity of the boiler, t/h	
	420	640
Specific capital costs, rub/kW	11,5	10,0
Capital costs, thous. rub.	1500	2000
Area for equipment installation, m^2	50	80
Energy consumption for desulfurization, % of equivalent electrical capacity	0,05	0,05

Table 1.24. **Indicators of desulfurization in Venturi scrubbers according to the dual alkaline technology**

Indicator	Steam-production capacity of the boiler, t/h		
	210	420	640
Capital costs, mil. rub.			5,0
Area for equipment installation*, m^2	150	200	300
Specific capital costs, rub/kW	35,5	27,0	25,0
Specific energy consumption, % of equivalent unit (boiler) capacity	0,07		
Reagent cost, rub/t: soda lime	 1150 850		

* Part of equipment is installed out of the boiler unit