Part 1

AIR PROTECTION FROM POWER INDUSTRY EMISSIONS

1.2. Ash collecting at TPPs

1.2.1. Fly Ash collecting and particulate emission standards at TPPs

1.2.1.1. Bases of fly ash collecting and particulate emission standards at TPPs

Prokhorov V.B., MPEI (TU)

An efficiency of ash collector operation is characterized by the following indicator:

$$\eta = \left(G_{in} - G_{out}\right)/G_{in} = \left(c_{in} - c_{out}\right)/c_{in}, \quad (1.1)$$

where η is an ash collection efficiency; G_{in}, G_{out} is an amount of ash at the inlet and outlet of the dust collector in unit time; c_{in}, c_{out} is an ash concentration at the inlet and outlet of the dust collector.

Sometimes, it is more convenient to use a value that characterizes the ash slip through the ash collector:

$$P = G_{\text{out}}/G_{\text{in}} = c_{\text{out}}/c_{\text{in}}. \quad (1.2)$$

Ash collection efficiency and its slippage are linked with the following equation:

$$P = 1 - \eta \quad (1.3)$$

At combustion of solid fuel at thermal power plants, ash collectors are compulsory installed. Depending on the required ash collecting efficiency, boiler capacity and ash characteristics, the following types of ash collectors can be used: inertial, scrubber, fabric ash collectors, and electrostatic precipitators. Derivation of the general ash collection equation, valid for all types of ash collectors at all geometric forms is given in [1]. From the ash collection equation follows that for small ash particles (less than 30 microns) wich are involved in the turbulent pulsations of the flow, the ash slip through the ash collector is determined by the formula:

$$\text{P} = \exp(-\Pi), \quad (1.4)$$

and for larger ash particles

$$P = 1 - \Pi \text{ or } \eta = \Pi \quad (1.5)$$

where Π is a parameter of ash collection,

$$\Pi = vA/V, \quad (1.6)$$

where v is velocity of ash particles under the influence of precipitation forces to the precipitation surface (drift velocity), m/s; A is a precipitation surface, m^2; V is volume of flue gas flow rate, m^3/s.

Fig. 1.23 shows a correlation between the ash slip and parameter of ash collection for small or large ash particles.

From Fig. 1.23 follows that the capture of large ash particles is more intense and fully completed at $\Pi = 1$. Small ash particles are caught in the dust collector not as intense and complete ash capture takes place at $\Pi \to \infty$. In all cases, the ash collection efficiency increases with increasing the ash collection parameter Π.

Let's replace the volume gas flow rate with the following expression:

$$V = u\omega, \quad (1.7)$$

where u is the gas velocity in the dust collector cross section, m/s; ω is a cross-section for gas passing, m^2.

Then the ash collection parameter can be written as follows:

$$\Pi = K\Phi, \quad (1.8)$$

where $\Phi = A/\omega$ is a geometrical parameter (shape parameter) of the ash collector, representing a ratio of precipitation surface to the cross section for gas passing, $K = v/u$ is a kinematic parameter, equal to a ratio of the drift velocity of ash particles to the gas velocity in ash collectors.

Ash collection efficiency is higher with more product of these parameters. Shape parameter depends on the geometric relationships in the ash collector, and the kinematic parameter is determined by the nature of the forces impacting the ash particle, its size, physical properties of particles and the gas flow, and aerodynamic characteristics of the flow.

Equations (1.4) and (1.5) were obtained by making some assumptions: there is no re-entrainment of the collected ash, all ash particles have the same drift velocity, uniform distribution of gas velocities over the cross section of the ash collector, so at the actual estimations of ash collectors, empirical correction has to be introduced.

Particles of different sizes have different drift velocity, so accurate estimates of the ash collecting efficiency should be carried out separately for each faction.

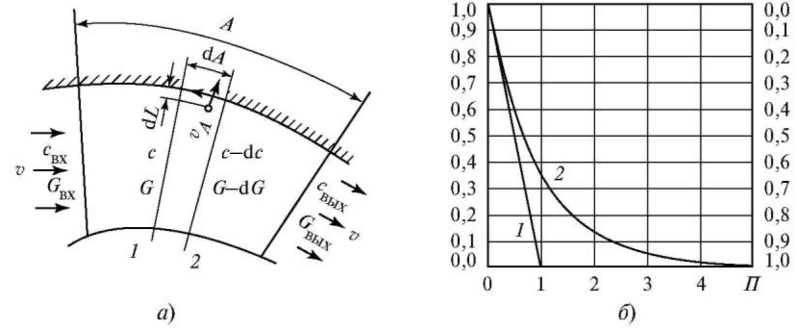

Fig. 1.23. Schematic diagram of ash collection (a) and correlation between the ash slip and ash collection parameter (b): *1* - for large particles that don't participate in the pulsations (larger than 30 microns); *2* - for fine particles (less than 10 microns);
$c_{\text{вх}}$ – c_{in}; $c_{\text{вых}}$ – c_{out}; $G_{\text{вх}}$ – G_{in}; $G_{\text{вых}}$ – G_{out}

According to ash sieving analyses there are the factions within the diameter, and hence the drift velocity changes slightly. For each fraction Φ_i the drift velocity v_p is estimated and it is used for determination of the fractional ash slip P_i. Ash total slippage is estimated by the formula:

$$P = \sum_{i=1}^{i=n} P_i \frac{\Phi_i}{100} \qquad (1.9)$$

where n is a number of fractions.

If several stages of ash collection are introduced in a sequential order, a slip of some fraction through all the stages is defined by the expression

$$P_i = P_{i1} P_{i2} P_{i3} \ldots, \qquad (1.10)$$

where P_{i1}, P_{i2}, P_{i3} is a slip of some fractions through the first, second and other stages of ash collection.

Currently the standards for specific fly ash emissions from TPP boilers [2], listed in Table. 1.8, are set.

Table 1.8. **Standards for particulate matters emitted with flue gases from boilers**

Boiler steam capacity D, t/h	Specific ash content of the fuel A_{sp}, % • kg/MJ	Mass emissions of particulate matters, kg/t ref fuel, for boiler plants put into operation		Mass concentrations of particulate matters in flue gases c_{out}, mg/m^3 (α= 1,4), for boiler plants put into operation	
		before 31.12.2000 г.	since 01.01.2001 г.	before 31.12.2000 г.	since 01.01.2001 г.
Before 420	Before 0,6	1,76	1,76	150	150
	0,6...2,5	1,76... 5,86	1,76...2,93	150...500	150...250
	Above 2,5	5,86	2,93	500	250
420 and more	Before 0,6	1,18	0,59	100	50
	0,6...2,5	1,18...4,7	0,59...1,76	100...400	50...150
	Above 2,5	4,7	1,76	400	150