Chapter 17
Technological Methods to Protect the Environment in the Ukrainian BOF Shops

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Abstract BOF process is one of the most productive ways of steel manufacturing. Byproducts of this process are metallurgical slag, gases (volatile-rich oxide and other chemical compounds), metallurgical dust, and excessive heat. Nevertheless there are developed a large number of waste gas cleaning systems and recycling technologies, these factors still have negative impact on whole biosphere. The greatest effect it makes on the atmosphere since during melting, a substantial amount of carbon and nitrogen oxides are released into the environment. The steelmaking dust can be classified by its origin. The main types of waste dust include: fragments of the raw material (as a result of technological overload and crushing of the raw materials), products of evaporation and condensation (vaporized molten slag and graphite ripe). For their capture in conditions of Ukrainian manufacturing developed a number of specific technological schemes involving precipitation of dust component in special units (Venturi tubes, cyclones, and scrubbers). Their use can reduce the concentration of hazardous substances and to the regulated legal framework limit.

17.1 Introduction

Metallurgy is the basis of the Ukrainian economic (11th place in world ranking of crude steel production). The most widespread method of steel production is Basic Oxygen Process (BOP) with top blowing. This high productivity technology allows producing low-carbon and carbon steel of ordinary quality. Steelmaking has a negative impact on the environment because of such wastes as slag, dust, and technological gases containing harmful volatile and dangerous substances and excessive heat. The greatest impact steel production has on atmosphere. Therefore, the main part of the technical solutions for environment protection in Ukraine is reducing emissions in atmosphere.

The aim of this work is to generalize and clarify information about the ways of protecting the environment that are used at the Ukrainian metallurgical plants and

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development of technical solutions for complex improvement of technological schemes of steelmaking in order to reduce the negative impact on the environment.

17.2 Affection of Harmful Factors of Steelmaking Production on the Biosphere

The share of ferrous metallurgy in Ukraine accounts for about 20–25 % of total harmful emissions into the atmosphere, and in the areas of the large steel plants is more than 50 % of all contaminants. Annually Ukrainian metallurgical plants emit in the atmosphere a huge amount of harmful substances (Table 17.1).

In addition, the steel industry is one of the largest water consumers. Modern steel plant consumes 180–200 m^3 of water to produce 1 t of rolled steel. Daily water consumption may exceed 3 million m^3. It includes cooling equipment—48 %, waste gas cleaning—26 %, metal processing—12 %, hydraulic transport—11 %, and others—2 % of water needs. Discharge wastewater from the steel plants in the pond increases the amount of suspended solids, much of which are deposited near the drain, raises water temperature, deteriorates oxygen regime. On the surface of the pond, an oily film can form due to emission lubricant products with water. If the effluents contain acid, it leads to change the water acidity and disturbing biological processes. Pollutants emission causes the death of aquatic organisms and interferes in the process of pond self-cleaning. Most metals, their compounds, and other inorganic substances contained in wastewater of metallurgical plants have harmful effects on humans and warm-blooded animals, flora, macro- and microorganisms.

Processes of steel production cause to forming large amount of solid waste, which accumulated on large areas and which have a harmful effect on the soil, flora, water sources, and air. Solid Waste Dumps now occupy thousands of hectares of mineral lands. Slag and dust waste are generated on almost all stages of steelmaking. According to approximate estimation to produce 1 t of steel used 4.7 t of raw materials, which produced 0.406 t of waste.

Now Ukrainian metallurgical plants have accumulated about 94 million tons of slag produced by steelmaking and ferroalloy industries that occupy about 800 ha. And this value significantly increases if we take into account the area occupied by waste of refractory from the worn lining of furnaces, ladles, and other aggregates. Thus it should be noted that the most dangerous factors is atmosphere pollution, which will be discussed further.

Volume of the gases produced by Basic Oxygen Furnace (BOF) is cyclical (Fig. 17.1) and depends on the rate of carbon oxidation and conditions of oxygen blowing.

Table 17.1 Average gross emissions of harmful substances into the atmosphere by metallurgical plants per year

Harmful substances	Dust	CO	SO_4	NO_x	H_2S	Suspended substances
Amount of emission, 1000 t	337.2	2638.9	207.4	296.5	3.3	194.8

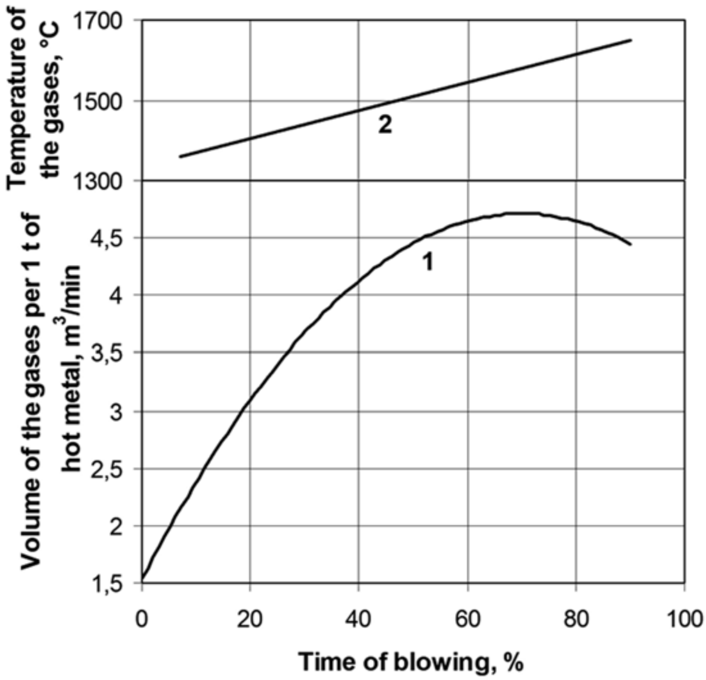

Fig. 17.1 Change of the BOF gases volume (*1*) and temperature (*2*) during oxygen blowing

Table 17.2 The chemical composition of BOF gases

Sampling point	Chemical composition of the gases, %			
	CO	CO_2	O_2	N_2
Near the BOF throat	85.0–90.0	8.0–14.0	1.5–3.5	0.5–2.5
In pipeline after full CO post-combustion	–	31.0	9.0	60.0

According to the practical data, volume of BOF gases that emits from the converter throat is 70–90 m^3/t of steel. The ratio of the maximum decarburization speed to the medium with using multinozzle lance is about 1.4. Table 17.2 shows the chemical composition of BOF gases.

In addition to the compounds indicated in Table 17.2 the following gas contents were revealed: 50 mg/m^3 SO_2; 100 mg/m^3 F_2 and 10 mg/m^3 Cl_2. Nitrogen oxides are not formed in the BOF workspace. However, the post-combustion CO to CO_2 leads to the formation of nitrogen oxides in amount of about 100 mg/m^3 or 50 g/t of crude steel. Nitrogen oxides are also formed in the post-combusted gases on the stack outlet in an amount of 30 g/t of steel. The BOF gases temperature at the outlet of its throat constantly increases during oxygen blowing. In the beginning of blowing it is 1250–1300 °C, and in the middle and at the end—1600–1700 °C.

During oxygen blowing BOF gases carry 1.5–2.0 % dust per 1 t of hot metal. Concentration of dust in the gases during blowing varies from 20 to 250 g/m^3 (or even more) and depends on many factors: the fume extracting and cooling system,

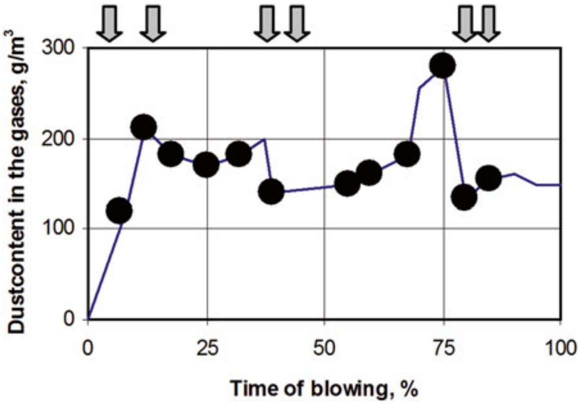

Fig. 17.2 Change of the gases dustiness during the blowing

Table 17.3 Average grain-size distribution of the dust emitted with the gases from the BOF

Particle size, μm	<3	3–60	60–250	>250
Mass fraction, %	65.0	7.0	9.0	19.0

oxygen blowing mode, quality, size distribution, and humidity of lime and other bulk materials charged during BOF blowing (Fig. 17.2). The maximum value of dust emissions observes at the time of charge the bulk materials (indicated by arrows).

The chemical composition of the dust little depends on the intensity of oxygen blowing, but varies greatly during periods of melting. Grain-size composition of dust can be divided into two groups: Fine, which is formed by the iron oxidation (<3 mm) and larger factions, which is formed by removal of slag and bulk materials particles (>3 μm). Grain-size and chemical composition of dust change during the melting. In periods of scrap and hot metal charging and also in the first minutes of oxygen blowing dust consists of large fractions (scrap pollution, particles of lime, etc.). Then the dust becomes fine disperse because of intensive combustion of iron in a reaction zone. Averaged grain-size distribution of dust emitted with the gases from the BOF is presented in Table 17.3.

The next stage of exploration was the complex analysis of technical solution for the atmosphere protection on Ukrainian metallurgical plants.

17.3 Technical Solutions for the Atmosphere Protection on the Metallurgical Plants

17.3.1 Cleaning and Cooling of the BOF Waste Gases

As though temperature of the gases emit from the vessel throat is very high, they must be cooled before the gas cleaning. Cooling can be carried out by injection of water in the gases. The disadvantage of this method is a significant increase of gas volume caused by forming of water vapor and inability of heat recovery. Thus this method is used only for partial cooling.

Application of waste heat boilers (WHB) is much better method that is widely used nowadays. Cooling by this method almost does not change the gases volume and allows recovering their warm.

17.3.2 BOF Pipeline

By way of the BOF gases emissions into the atmosphere pipelines are divided into three groups:

1. systems with air leakage through the slit between the BOF and WHB and the full post-combustion of CO to CO_2, i.e., air flow factor $\alpha > 1$;
2. systems with partial post-combustion of carbon monoxide in the WHB, i.e., at $0.0 < \alpha < 1.0$;
3. systems without air leakage in the pipeline and without post-combustion of carbon monoxide, i.e., at almost $\alpha < 0.15$.

Mode of pipeline is determined by the pressure maintained in the slit between the BOF and the WHB.

If at the slit there is kept sufficiently large rarefied, then ambient air is injected in WHB with the BOF gases. Amount of injected ambient air is sufficient for combustion of the BOF gases, i.e., $\alpha > 1.0$. In this case, the pipeline works in a mode of full post-combustion of carbon monoxide.

If at the slit there is kept little rarefy, the volume of injected ambient air is insufficient to complete post-combustion of carbon monoxide and pipeline works in a mode of partial post-combustion of CO to CO_2.

Depends on rarefy at the slit through the pipeline will pass complete combustion products, not post-combusted BOF gases or partially post-combusted gases. It should be noted that converter gas is explosive when $\alpha < 0.75$. To avoid explosion it needs to exclude the possibility of a collision BOF gases with air, especially in low temperatures areas, where the gases do not burn and form explosive mixtures.

This requires good hermetic of pipeline and complete exclusion of air leak in it. It is also necessary to move volume of inert gas right afore and behind explosive gases (CO_2 and H_2).

For slit pressures higher than the atmospheric one, air does not leak in the pipeline and post-combustion of carbon monoxide does not occur ($\alpha \approx 0$). Since in this mode the gases can be released into the shop atmosphere, then minimal rarefy at the slit is maintained ($\alpha = 0.11$–0.15).

The rarefy value in slit is regulated by the flap in the pipeline before the smoke exhauster.

Volume of the gases that come to the gas clearing system with full post-combustion of carbon monoxide is 3–5 times more than volume of the gases formed during the blowing. It results to increase in size of the pipeline, the system of gas clearing, power and energy consumption of smoke exhauster. Use of such system with the BOF capacity over 200 t is economically inefficient. But it should be installed for the BOF of smaller capacity, because of complete safety.

Table 17.4 Dependence of volume of the gases from the air flow rate

Air flow rate, α	1.0	0.75	0.15	0.07
Volume of emitted BOF gases, m^3/h	1000	1200	1700	3600
%	100	120	170	360

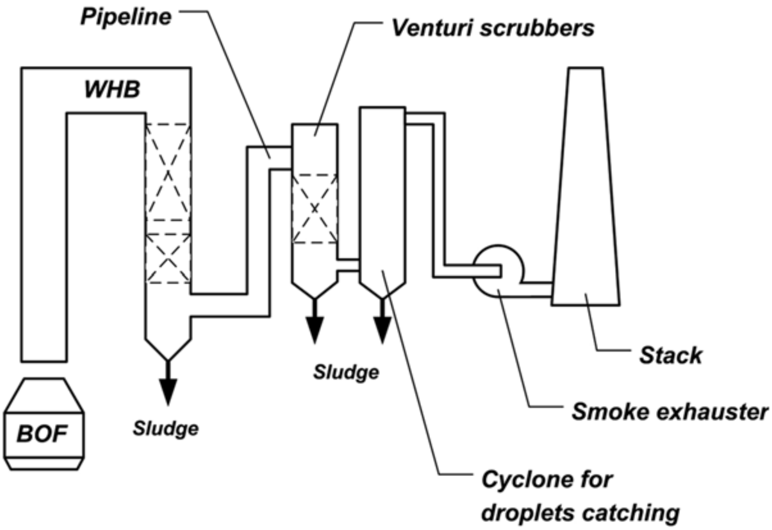

Fig. 17.3 Scheme of system for cooling and cleaning of the BOF gases with full post-combustion CO

The value of the air flow rate α for post-combustion of carbon monoxide significantly impacts on the capacity of the pipeline (Table 17.4).

Thus, the same volume of BOF gases would need much smaller pipeline if value of air rate α is small. Switching BOF from a full system of CO post-combustion ($\alpha > 1.0$) to the partial post-combustion system or without any post-combustion of carbon monoxide can significantly increase the intensity of blowing and consequently improve BOF productivity.

17.3.3 Units with Full Post-Combustion of Carbon Monoxide

Plants of this type are widely used in Ukraine (Fig. 17.3). In the fireplace above the BOF CO burns by air which leaks through the fully open slit between the BOF and the fireplace.

After passing through the WHB the dusty gases significantly change chemical composition and size of dust particles. Because of particle precipitation, especially its large fractions of dust in WHB pipes the concentration of dust in the gases before

Table 17.5 Grain-size composition of dust before cleaning, %

Time of blowing, min	Dust fraction, μm			
	<3	3–60	60–250	>250
1–5	60	15	15	10
18–14	82	3	5	10
18–22	86	5.5	5	3.5

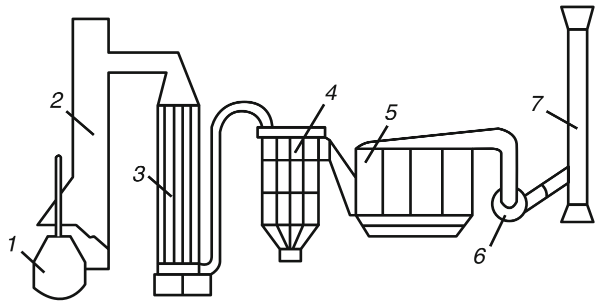

Fig. 17.4 Scheme of gas cleaning in baghouse: (*1*) the BOF; (*2*) cooled fireplace; (*3*) regenerator; (*4*) evaporative scrubber; (*5*) baghouse; (*6*) smoke exhauster; (*7*) stack

cleaning is up to 25–60 g/m^3. On this stage dust mostly consists of iron oxides. Mass fraction of fine fraction increases to the end of blowing (Table 17.5).

After WHB gases flow to the clearing, which in all Ukrainian BOF plants is carried out in Venturi scrubber. Since after Venturi scrubbers cleaned gases still contain dust within water droplets that have harmful effect on the pipes and smoke exhausts, they are treated in droplet catcher and then thrown through the chimney in the atmosphere.

In many countries dry and wet electrostatic precipitators (ESP) and sometimes baghouse are widely used for cleaning of the BOF gases. Fabric filters are used in France, Belgium, USA etc. (Fig. 17.4) for BOF gases cleaning.

In case of BOF gases cleaning without heat recovery, the gases from the converter (1) flow in the cooled fireplace (2), where they are post-combusted and cooled, and then sent to the regenerator (3). When flowing through vertical refractory channels of regenerator, gases give them their heat. Final cooling of gases before baghouse (5) is carried out in evaporation scrubber (4). After the BOF blowing atmosphere air is flown through the regenerator and cooled its checker. The final concentration of dust in the gases that released into the atmosphere through the smoke exhauster (6) and chimney (7) is 4.7 mg/m^3.

The cleaning of the BOF gases by cloth filters is also performed with heat recovery. In this case for cooling of the gases instead of regenerator the WHB is used.

17.3.4 Units with Partial Post-Combustion of Carbon Monoxide

There are two modes of the unit with partial post-combustion of carbon monoxide: in the first mode the system does not combust CO completely ($0.75 < \alpha < 1$); the second—with the partial combustion of carbon monoxide at $0.3 < \alpha < 0.6$. The principal difference between these modes is that in the first case gases in pipeline cannot burn, and the second—they are explosive.

Saturated with moisture gases flare up and burn if consist of at least 20–25 % CO. The disadvantage of the first mode ($0.75 < \alpha < 1$) is that the amount of carbon monoxide in the gases at the outlet of the stack are much lower. Thus the gases cannot be post-combusted and significant volume of toxic CO is emitted in atmosphere.

In the mode of partial post-combustion of CO ($0.3 < \alpha < 0.6$), CO content is more than 25 % during the most of the blowing time and gases post-combust. The slit between the BOF and the WHB is entirely open in this mode. Smoke exhauster is set up to constant productivity that is on 10–15 % more than volume of the BOF gases in the period of maximum gas emission.

In the initial period of BOF blowing when exhaust gases consist little CO, the system operates in the mode of full post-combustion and there are oxygen and carbon dioxide in the pipeline, but not carbon monoxide. That is not explosive exhaust gases.

Excess volume of oxygen in the exhaust gases rapidly decreases with increase of the total volume of gases emits from the BOF (i.e. air flow through the leak remains the same and the volume of CO in the gases increases) and when $\alpha = 1$ is about zero. At this time exhaust gases almost do not content CO that completely combusted to CO_2. Formed volume of inflammable gas ($CO_2 + H_2$), is blown through pipeline and clears it from remaining oxygen. Right after the volume of inflammable gas another gases flow that consists of carbon monoxide but no oxygen. After the end of blowing the same processes occur in the opposite direction. So volume of inflammable gas that is formed in the initial period and at the end of blowing reliably separates the transported gas. That does not allow mixing transported gas with air and CO to form explosive gas mixtures. In this mode BOF gases cannot be used as fuel. The BOF gases with a high content of CO are formed and flow out the throat in the pipeline just for 6–10 min, i.e., less than 50 % of blowing time.

Waste gas could not be used as a fuel in the last period of the BOF melting because of reduces of CO content. Thus in all systems with partial post-combustion of CO the BOF gases is burnt on the stack before release in the atmosphere.

In systems with partial post-combustion of CO dust content in the gases before cleaning is a little more (30–80 g/m^3 of gases) than in systems with full post-combustion of CO because of less air leak in the gases. Weight of the formed dust is the same as in the full post-combustion, but dust concentration is more as a result of the much less air leak in the gases and consequently less volume of waste gases.

The chemical and grain-size composition of dust in systems with partial post-combustion of CO are almost the same as in the system with full post-combustion CO.

By employing wet dust-catcher (Venturi scrubber) the mode of full CO post-combustion can be easy shifted on partial CO post-combustion. It is needed just to seal pipelines, mainly in its coldest part (gas temperature below 800–900 °C), to eliminate the possibility of formation of dead air zones, equip the stack with burner,

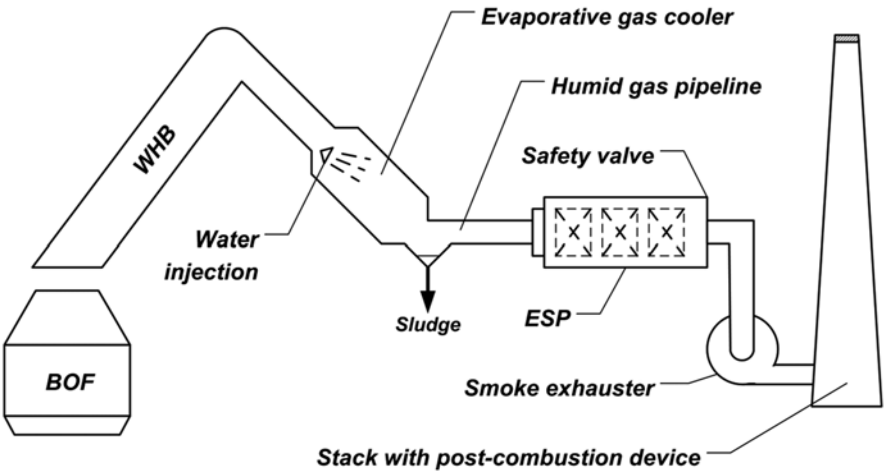

Fig. 17.5 Scheme of unit for cooling and cleaning in ESP the BOF gases with the partial CO post-combusting

and make the pipeline of the each BOF unit autonomous. Operation of gas-path does not become more complicated, but rather simplifies, since there is no need for any regulation while maintaining complete safety.

One of the reasons of the wide application of wet type units (Venturi scrubber) to clean the BOF gases regardless of a number of disadvantages (high water consumption, systems for its cleaning, sludge processing, corrosion of equipment, etc.) is dangerously explosive gas mixture in the case of ESP application. Some of the European and US plants use gas cleaning system with ESP (Fig. 17.5).

The unit includes evaporative gas cooler, through which the high-temperature gases (~1000 °C) are flown. Their temperature depends on the top blowing mode in the BOF and the effectiveness of the WHB. In the evaporative gas cooler the gases temperature is reduced to about 200 °C due to injection of carefully regulated volume of water that completely evaporates. Then gases are directed, by smoke exhauster to the stack with post-combustion device.

Such gas-cleaning units operate with minimal air flow rate of $\alpha = 0.2–0.6$ and provide clean gases emitted through the stack to dust concentration of about 30–50 mg/m^3.

17.3.5 Units Without Carbon Monoxide Post-Combustion

When using the BOF of more than 250 t and blowing intensity more than 4.0 m^3/(t·min) the volume of the gases significantly increases. Calculations show that in that case installation of the unit with complete CO post-combustion is economically inefficient. The unit without CO post-combustion is more rational because the volume of the treated gases and therefore the size of the gas pipeline reduce 3–5 times. Smaller size of the pipeline favours installation and operation.

Before treatment the gases consist of (volume): CO_2—17 %; N_2—16 %; and CO—67 %. In addition, the gases contain (mg/m^3): SO_2—70; H_2S—30; F—200; and Cl—20. After treatment gases can be recycled and used as fuel.

Due to the lack of combustion in the pipeline chemical and grain-size composition of dust emitted from the BOF almost do not change and are the same as when using devices with full or partial CO post-combustion. The dust content in the gases at the BOF throat is up to 200 g/m^3.

Without CO post-combustion the possibility of formation of explosive mixtures of oxygen and carbon monoxide in the pipeline significantly increases. That's why all Ukrainian BOF plants, without CO post-combustion, are equipped with wet type (Venturi scrubber) gas cleaning units.

Safety of operation, as in units with partial CO post-combustion, is provided by forming volume of inflammable gas mixture ($CO_2 + N_2$) that in the initial period and after the blowing reliably separates explosive volumes and prevents their mixing. Formation of the volume of inflammable gas provides a hood, which hangs over the BOF.

A rectangular Venturi tube with an adjustable throat section is widespread in the big BOF plants working without CO post-combustion (Fig. 17.6).

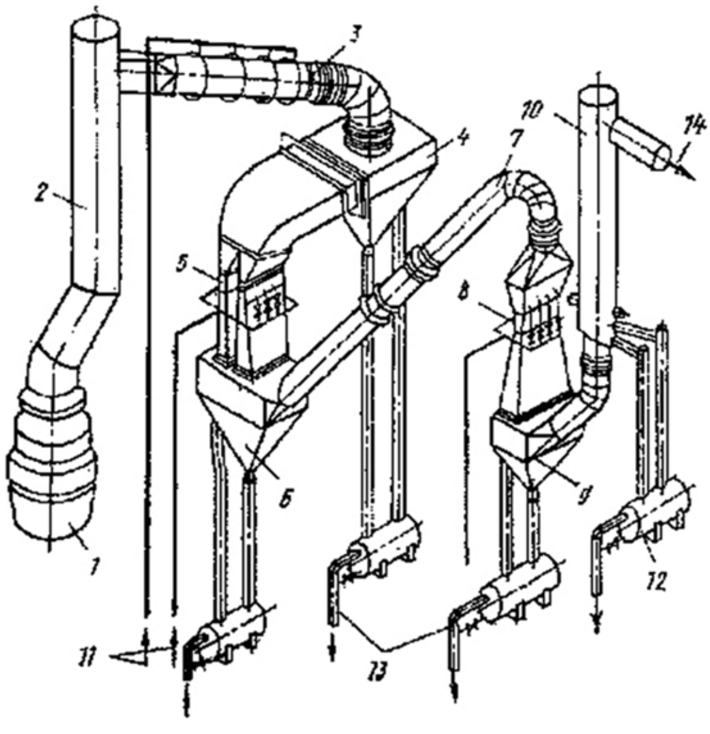

Fig. 17.6 Scheme of gas cleaning units equipped with Venturi scrubbers for the 300 t BOF capacity: (*1*) the BOF unit; (*2*) the WHB; (*3*) pipeline with water injection; (*4*) hopper of water injection pipeline; (*5*) Venturi tubes of the first stage; (*6*) hopper of the first stage; (*7*) connecting pipeline; (*8*) adjustable Venturi tube of the second stage; (*9*) hopper of the second stage; (*10*) droplet catcher; (*11*) water supply to the water injection pipeline; (*12*) hydraulic lock; (*13*) removal of sludge; (*14*) supply of gas to the smoke exhauster

After the WHB (2) gases with a temperature of 750–1000 °C are directed into water injection pipeline (3). Water supply (11) to the pipeline is carried out with circulating. The water cools the gases to 250–300 °C. The hopper of water injection pipeline (4) is adjacent to two Venturi tube of the first stage cleaning (5). From the Venturi tubes hopper (6) gases make the turn by connecting pipeline (7) and flow to the second stage of treatment—the adjustable Venturi tube (8). Then after the hopper (9) the gases come to droplet catcher (10), from which through the pipeline (14) sucked by smoke exhausters and post-combusted in the stack outlet.

Such BOF cleaning units mostly equipped with shortening Venturi tubes with disk spraying (Fig. 17.7).

The gases that flow out of the BOF (1) after WHB (2) with a temperature of 750–1000 °C reach the unit of preliminary water injection and then are directed into the shortened Venturi tube (4) equipped with moisture separator (5) and the hopper of the first stage (6). Then the gases are sent through the shortening Venturi tubes of the second stage (7) in the hopper of the second stage (9). After that the gases through

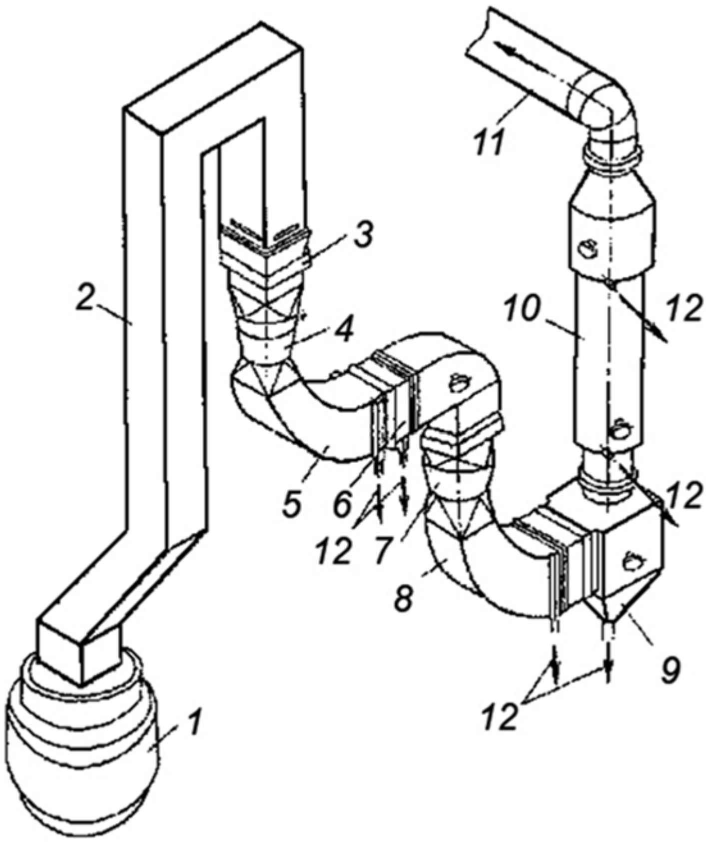

Fig. 17.7 Scheme of the BOF gas cleaning units with shortening Venturi tubes for capacity 350–400 t: (*1*) the BOF; (*2*) WHB; (*3*) unit of preliminary water injection; (*4*) the shortening Venturi tubes of the first stage; (*5*) moisture separator; (*6*) hopper of the first stage; (7) the shortening Venturi tubes of the second stage degree with disk control; (*8*) droplet catcher; (*9*) hopper of the second stage; (*10*) centrifugal droplet catcher; (*11*) pipeline to smoke exhauster; (*12*) removal of sludge

the centrifugal droplet catcher (10) by pipeline (11) are sucked by smoke exhausters and emitted through the stack. The gases are post-combusted on the stack outlet.

In order to improve the reliability of operation the following amendments in gas cleaning units were made.

– highly dispersed water injection in the top of the lifting pipeline in order to faster solidification and cooling of dust particles, and to avoid slagging of WHB top lid;
– replacement of pipeline with water injection and the shortening Venturi tubes of the first stage by hollow scrubber with water injection. These amendments simplify pipeline, reduce its hydraulic resistance, allow to get rid of large fractions of dust and pieces of sludge, reduces abrasive wear and prevent clogging of sludge duct;
– installation of the second droplet catcher before the smoke exhauster to protect the last from drops formed due to cooling gas saturated with moisture.

17.4 Decrease of Unorganized Emission of Harmful Substances into the Atmosphere on Metallurgical Plants

Gas and dust emissions directly emitted in the atmosphere are called unorganized emissions.

In steelmaking shops unorganized fugitive emissions happen while overloading charge materials (scrap, limestone, lime, etc.), filling and pouring hot metal in mixers, removing of slag from mixers and ladles, tilting of the BOF for charging sampling and tapping, secondary treatment of steel and casting in ingots or continuous casting machine (CCM), preparation for work and repairing of technological units.

There are no forced ventilation systems in the steelmaking shops. Ventilation is carried out by aeration lanterns. Therefore, in all areas where there are unorganized emissions of gas and dust in the atmosphere an aspiration system needs to be installed. The most simple aspiration system for the treatment of unorganized emissions is shown in Fig. 17.8.

When using this system gas and dust emissions from the source are caught by umbrella and by the fan or smoke exhauster transported through pipeline to the hopper chamber. In the hopper chamber dust particles are deposited due to gravitational forces and purified air (smoke) emits through the stack into the atmosphere. Hopper chamber, smoke exhauster, and stack are installed out of shop.

Among the steelmaking units the mixer is one of the main suppliers of unorganized emissions in the atmosphere (Table 17.6). While pouring hot metal 0.02–0.05 % of its weight becomes the dust.

For mixers 2500 t capacity as the first stage of gas cleaning system the cyclones are recommended, and for the second stage—baghouse or ESP. Baghouse cannot fire because the red-hot iron particles, talc, and graphite foam are completely caught in the cyclone. Electrostatic breakdown of ESP insulation is also impossible, because after the first stage of treatment there is no electrically conducting graphite foam in the gas.

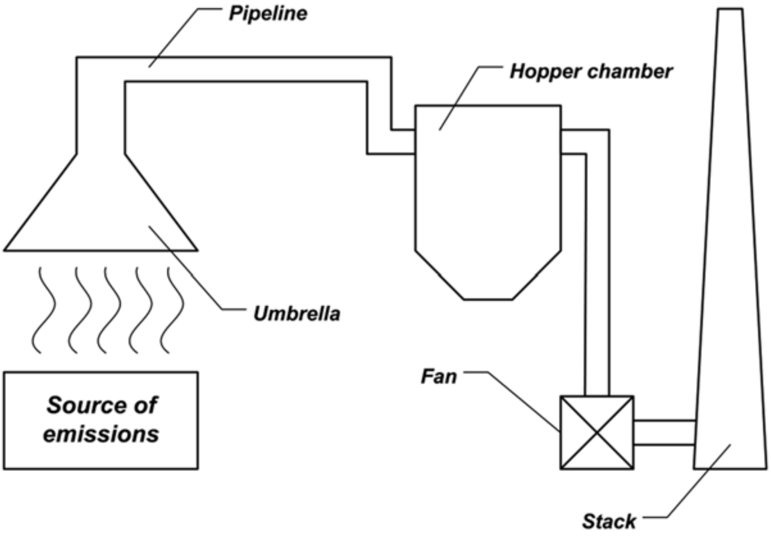

Fig. 17.8 Aspiration system for unorganized emissions

Table 17.6 Parameters of the gas and dust emission from mixers

Technological process	Mixer capacity, t 600	1300	2500	Temperature of gases, °C
Filling of hot metal	114/0.22[a]	139/0.45	150/0.52	30–40
Slag skimming	82/3.1	67/1.9	61/2.2	70–90
Pouring of hot metal	44/0.46	65/1.06	85/4.13	50–180

[a]Numerator—volume of the gases, m^3/s; denominator—dust content in the gases, mg/m^3

In order to reduce air leakage in the pipeline the smoke exhausters should be installed before gas cleaning unit. Thanks to lubricating qualities of graphite foam, there is no abrasion wear of smoke exhausters in this case.

The unorganized emissions also can be decreased by the formation of a neutral atmosphere in the iron ladle. It can be done by filling the ladle with neutral gas or by burning natural gas in it. The neutral atmosphere in the iron ladle prevents formation of iron oxides and emission of brown smoke.

In the BOF shops the unorganized emissions reach its maximum value while filling hot metal after scrap charging. The emissions include up to 35 % FeO and 30 % graphite foam in the form of particles smaller than 100 μm. Volume of emissions mostly depends on scrap quality and filling speed. Its value can be reduced by using less contaminated scrap. During steel tapping in a teeming ladle a dense smoke is formed that contains dust (less than 100 μm), which consists of up to 75 % FeO.

The aspiration system is employed to catch unorganized emissions there are successfully used the aspiration system, which include umbrella, although they suck a lot of air. The umbrellas require minimal workspace and do not disturb staff. On the contrary, local extraction near the sources of dust is more effective, but its operation is more complicated.

Sometimes, to catch unorganized emissions caused by the BOF charging the umbrellas in combination with fabric filters or scrubbers are used. Aeration systems are also installed in the department of bulk materials at the transport devices and supply hoppers.

The optimal solution to eliminate unorganized emissions is the isolation of the BOF vessel using gas-tight storage ("dog house"). Efficiency of this system is about 90–95 %.

There is performed different kind of operation with refractory in yard of teeming ladles preparation. Replacement or partial repair of lining forms significant amounts of dust. According to various sources its value can range from 0.01 to 0.2 kg of dust per 1 t steel. While drying and heating the recorded emissions were (kg/t of steel): SO_2—0,01; CO—0.1; NO_x—0.1; and some CH_4. At this site there are widely used the aspiration systems with umbrella, local extraction of contaminated air, and lids on the ladles. Application of unshaped refractory lining in the form of liquid concrete as well helps to reduce emissions.

17.5 Conclusions and Recommendations

Volume of gases produced during the BOF melting depends on:

- blowing mode,
- type of additives,
- lance design,
- height above the bath surface,
- hot metal composition,
- blowing intensity,
- vessel capacity.

and according to practical data is 70–90 m^3 per 1 t of vessel capacity.

One of the effective ways to reduce emissions is application of multinozzle lance.

Volume of the BOF gases depends on oxygen consumption for carbon oxidation. Application of the modes with partial or without CO post-combustion significantly reduces the volume of the BOF gases and dust. It also could be reached by the following measures:

- fast forming of a homogeneous slag,
- use of bulk materials without fine fractions,
- optimal composition of hot metal,

- scrap clean of nonmetallic materials,
- reducing the blowing intensity at the time of bulk materials charging.

Reducing the amount of the dust also occurs when charging bulk materials in the vessel before or at the very initial stage of the blowing with small volume of the formed gases.