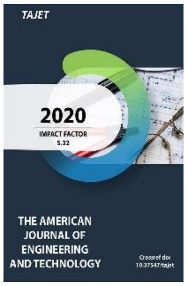

Analysis Of The Processes Of Using The Exhaust Gases From Arc Steel Melting Furnaces For Raw Material Heating

Khalikulov U.M.
Senior Lecturer, Almalyk Branch Of NUST "MISiS", Uzbekistan

ABSTRACT

This article analyzes the main problems and solutions to the preheating of raw materials with the help of off-gases during melting in electric arc furnaces (EAF). The analysis of the available developments in this direction and the ways of introducing this process into the EAF of the electric steel-making shop of JSC "Uzmetkombinat" was carried out. Features come from a number of parameters and criteria of raw materials, the composition of the charge and the technology implementation during the melting period.

KEYWORDS

Technological process, aerodynamic properties of gases, JSC "Uzmetkombinat", hot briquetted iron, electric arc furnace, Charge composition, high temperature, electric arc furnace.

INTRODUCTION

The current trend in the development of heavy industry, mechanical engineering, automotive industry, an increase in construction sites and many other sectors of the global economy requires a significant increase in demand for ferrous metallurgy products, and it occupies one of the key manufacturing sectors in the economics of all countries. Accordingly, this process has a significant impact on development in other industrial sectors.

For example, according to the World Steel Association, steel production in the world in 2019 increased by 4.6% and reached 1808.6 million tons, according to the data of 64 major states that smelt metals. According to the World Steel Association (Worldsteel), in May 2020, steel production in 64 countries that

IMPACT FACTOR
2020: 5. 32
OCLC - 1121105677

submit their statistics to this international organization amounted to 148.8 million tons, which is 8.7% less than in the same month last year. At the same time, the average daily production amounted to 4.799 million tons, which is 9.0% higher than the April figure. Thus, the extreme point of the recession in the global metallurgical industry caused by quarantine measures was left behind.

It should be noted that at the current stage of its development, Uzbekistan is colossally increasing its production capacity and the volume of construction sites. Accordingly, a natural tendency is formed towards an increase in the internal consumption of structural steel. This tendency obliges to increase the capacity of the domestic steel production industry. Most of the load in the production of steel products falls on the shoulders of JSC "Uzmetkombinat" located in the city of Bekabad, Tashkent region.

Almost all pyrometallurgical processes are characterized by the formation of large quantities of gases and dust. These two products are removed from the ovens together. At the same time, dust and gases of pyrometallurgical technologies serve as a source of environmental pollution.

Therefore, their capture, use and disposal are the most important problems of modern metallurgical production.

Waste metallurgical gases are divided into process gases, generated by chemical reactions, and furnace gases, which are products of fuel combustion. The composition and quantity of waste gases is completely determined by the type of raw materials processed and the type of metallurgical process used.

The main components of process gases are SO_2, CO_2, CO and water vapor. In some metallurgical processes, chlorine gas, arsenic and other chemical compounds can be released.

When fuel is burned, CO_2, CO and H_2O are predominantly formed.

In addition, nitrogen and free oxygen are necessarily present in the exhaust gases, which are supplied in excess with blowing and due to air leakage.

In most cases, the exhaust gases leave the metallurgical unit heated to a temperature of 800–1300 ° C and more.

Comprehensive waste gas processing includes:

- The use of valuable components, for example, SO_2, for the production of sulfuric acid, elemental sulfur or liquid sulfur dioxide;
- The use of the physical heat of gases to generate steam, hot water, air heating (blast), etc.
- Neutralization of gases in order to protect the environment with the simultaneous use of the valuable components contained in them.

The most valuable are waste gases from pyrometallurgical processes, containing up to 80% SO_2 and heated to 1300 ° C and more.

For the purpose of objectivity of the issue under study, this process should be considered through the prism of physical processes of pre-heating of scrap, in which a number of simultaneously occurring physical processes that occur in metallurgical units and possible heaters are accompanied. The main phenomena affecting the process of heating scrap metal are:

Published: November 29, 2020 | **Pages:** 81-88
Doi: https://doi.org/10.37547/tajet/Volume02Issue11-13

IMPACT FACTOR
2020: 5. 32
OCLC - 1121105677

a) The formation of waste gas heat by steel melting units,
b) The process of transferring heat from waste gases to a metal charge,
c) Gas formation in steel smelting units and afterburning of waste gases.

The process of preheating the metal charge is based on the use of the physical and chemical heat of the waste gases, which, passing through the cold metal charge, give up part of their heat. The heat of the waste gases in the total energy balance of the EAF is from 12 to 25% for the entire melting period. The heat of the waste gases in an electric steel furnace consists of the following energy sources:

- part of the heat of electrical energy, which is introduced into the furnace space to melt the charge and bring the melt to the required temperature. The active power of AC EAF, introduced into the furnace space, depends mainly on the voltage level, operating current and reactance:

$$Pa = 3I\sqrt{\frac{U^2}{3}} - (I - X)\,(1)$$

where Ra is the power of electric arcs; I is the operating current; U - arc voltage, X - reactance of the furnace electric circuit.

This heat is carried away by the flow of exhaust gases from electric arcs and by radiation of heat from the surface of the liquid bath of the furnace. The amount of heat of electrical energy, which is carried away by the exhaust gases, largely depends on the phase and operating mode of the furnace and is approximately 6-8%.

- heat introduced by fuel-oxygen burners. For combustion, mainly natural gas or other types of fossil fuels are used. The heat released during the combustion of 1 mole of natural gas or coal is determined according to the equations of chemical reactions:

- $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ $\Delta H^\circ = -802.9$ kJ / 0.22 kWh (2)

- $C + O_2 \rightarrow CO_2$ $\Delta H^\circ = -393$ kJ / 0.11 kWh (3)

- heat of chemical reactions that take place in the furnace bath during the redox periods of melting. These chemical reactions take place at the liquid metal - slag interface and in the space above the slag. They generate or take away heat, i.e. are exothermic or endothermic in nature.

- heat of chemical reactions that occur in the induced slag of the electric furnace. These reactions generate heat in a relatively short phase of the furnace operation. Table 1 shows the main exothermic reactions of elements and gases that take place in the furnace space.

Table 1. Heat effects of oxidation of elements and gases

Reactions:	The release of energy during reactions
$Si + O_2 \rightarrow SiO_2$	-8.70 kWh / kg Si -10.92 kWh / m3O2
$Mn + 0.5\ O_2 \rightarrow Mn\ O$	-1.95 kWh / kg Mn -9.56 kWh / m3O2
$2\ Cr + 1.5\ O_2 \rightarrow Cr_2O_3$	-3.05 kWh / kg Cr -9.44 kWh / m3O2
$S + O_2 \rightarrow SO_2$	-2.75 kWh / kg S -3.94 kWh / m3O2
$2\ Fe + 1.5\ O_2 \rightarrow Fe_2O_3$	-2.03 kWh / kg Fe -6.74 kWh / m3O2
$Fe + 0.5\ O_2 \rightarrow FeO$	-1.32 kW • h / kg Fe -6.58 kW • h / m3O2
$C + O_2 \rightarrow CO_2$	-9.10 kW • h / kg C -4.88 kW • h / m3O2
$C + 0.5\ O_2 \rightarrow CO$	-2.55 kWh / kg C -2.73 kWh / m3O2
$CO + 0.5\ O_2 \rightarrow CO_2$	-2.81 kWh / kg CO -1.75 kWh / m3O2

- heat generated when blowing into the furnace space, carbon in the form of powder or lump coal. This coal is mainly used to induce foamy slag or as a source of cheap energy. The heat generated by burning coal (assuming a pure carbon content) is determined according to equation 1.

- heat of combustion of electrodes, combustion of oils and other organic substances in the metal charge. In modern electric arc furnaces, the consumption of electrodes is approximately 1.8 to 1.2 kg / t. The content of oils and other organic substances, which are mainly hydrocarbon compounds, make up from 5 to 8% in household scrap metal. For the afterburning of carbon monoxide, which is formed in the working space of the particle board, oxygen is blown in with special tuyeres. Carbon oxidation reactions go through the following stages:

2C + O2 → 2CO - 2.85 kW • h / kg C (4)

2CO + O2 → 2 CO2- 6.55 kW • h / kg C (5)

These reactions generate a significant amount of heat, which is carried away by the waste gases and can use for heating the metal charge. Table 1.2 shows the data on the power of heat losses of waste gases of various types of EAF.

Table 2. Power of heat losses of waste gases of various types of EAF

Unit type.	The amount of heat losses, kW • h / t	Percentage,%
Chipboard 100 t, alloy steel	168	21.1
Chipboard 120 t, stainless steel	127	18
Chipboard 80 t, with scrap	100	14

preheating		

The amount of gases that forms in the furnace space is determined by many factors that can vary within wide limits, depending on the capacity and power of the EAF, the steel grade, the method of conducting the technological process, methods of intensification and other characteristics of the process. The intensity of gas formation in EAF is characterized by three periods:

-melting period,

-oxidative period,

-recovery period.

The specific amount of gases formed in the furnace space of the EAF per unit time is calculated using the expression:

$$Vr = 1{,}87 \bullet 10^{2}\,(10\Delta C + M_{з} + 1{,}2 \bullet 10^{-3}\,M_{з} \bullet a)/\tau\,(CO + CO_2) \quad (6)$$

/ t; a - the content in lime is not finished,%; τ is the duration of the arcs, h; CO and CO_2 - their average content in the gases of the working space,%. The expression is based on the equation of the material balance of carbon per melt. However, it does not take into account the maximum values of the intensity of gas evolution during the melting period and during the oxidation of the melt, when gas-oxygen burners and lances for blowing the metal with oxygen are switched on.

During the period of metal melting with the use of gas-oxygen burners, the amount of gases arising in the furnace space is determined by the expression:

$$Vr = V_{CO} + Vco_2 + V_{H_2O} + V_B - V_{O_2} \quad (7)$$

where VCO and Vco2 are the amount of CO and CO2 at the outlet of the working space, m3 / h; Vh2o is the amount of steam at the furnace outlet, m3 / h; Vb is the amount of air sucked into the working space, m3 / h; Vo2 in - the amount of air oxygen consumed for the combustion of CO in the working space, m3 / h;

The most intense gassing occurs during the oxidation period of the smelting. The total volume of gases at the outlet of the working space of the furnace Vr, m3 / h is determined using the expression:

where Vr is the average spec

$$Vr = V_{CO} + Vco_2 + V_B - V_{O_2}\,B \quad (8)$$

The data given in various works on the specific amount of exhaust gases from the furnace space are very different from each other and lie in the range from 40 to 600 m3 / t • h, that is, they differ by an order of magnitude. Table 3 shows the averaged data for high power EAF using oxy-fuel burners [31-35].

Table 3. EAF gases output during the oxidation period of melting

Chipboard capacity, t	50	80	100	120	150	200	250
Specific gas flow, st.m3 / t• h	600	437	400	375	366	325	320
Gas quantity Vr, st. m3 / h	30.000	35.000	40.000	45.000	55.000	65.000	80.000

The temperature of gases at the outlet from the working space of the furnace for the melting period with the use of gas-oxygen burners is determined by the expression:

$$T_r = [(1 - \eta r)\, Q^P_{CH_4}\, V_{CH_4}]/V_r\, C_r) \quad (9)$$

where ηr is the efficiency burners is taken equal to 0.4-0.6; $Q^P_{CH_4}$ - calorific value of natural gas, kJ / m3; Cr is the average heat capacity of gases at the outlet from the working space, kJ / (m3 deg).

For the period of blowing the metal with oxygen, the temperature of the gases at the exit from the working space of the furnace is determined by the expression:

$$T_r = V_{CO_2}[C_{CO} t_{CO} + (0{,}3 \div 0{,}5) - Q^P_{CO}]V_r\, C_r \quad (10)$$

where C_{CO} is the average heat capacity of CO, released from the bath, kJ / (m3 deg); t_{CO} is the temperature of CO released from the bath, ° C (taken equal to the metal temperature); Qpco-heating value of CO, kJ / m3;

Calculations of the flue gas temperatures and practical measurements show that the maximum flue gas temperatures are reached during the smelting period and the oxygen purging period. Table 4 shows the data on the temperature zones of the exhaust gases of EAF units using gas-oxygen burners.

Table 4. Range of flue gas temperatures depending on the phase of operation

Oven operation phases:	Temperature zone, ° C
Melting period	800 -1750
Oxidation period	1200-1600
Recovery period	1400-1600

CONCLUSIONS

In general, the analysis of existing work in the direction of preheating the charge shows that in the dynamics of its development and the application of the process of preheating scrap metal in steel production, a wealth of theoretical and practical experience has been accumulated. Analysis of the studied literature in this direction, which is only the main one in this area, shows how much attention has been paid in the past by scientists and practitioners to this topic. At present, in this area, intensive theoretical research and practical experiments on the development of this process continue. It proceeds from the urgent problem of saving energy resources, preserving the environment and reducing the cost of steel production.

However, despite the richly accumulated theoretical and practical experience in this area, many problems of preheating scrap metal remained unsolved. Based on literary sources, it is possible to chronologically divide the development of the processes of preheating scrap metal into the following periods:

Period of the 70s. Scrap metal heating with exhaust gases in a vessel outside the furnace unit.

Period of the 80s. Scrap metal heating in charge supply systems (continuous supply with simultaneous charge heating).

Period of the 90s. Scrap metal preheating in shaft furnaces (scrap metal heating units integrated with chipboard).

The period of the early 2000s. The process of batch heating and feeding of the charge into the particle board, the "COSS" process.

In the dynamics of the development and use of preheating of scrap metal in steel production, a stable trend and practical experience have been formed. Accordingly, from the preliminary analysis presented in this work, which is only the main one in this area, it can be determined that on the part of researchers, attention is focused only on the technological aspect. At the same time, an important factor of stability is the problem of reducing the cost of steel when using these technologies.

In general, theoretical research and practical experience in the development of this process shows that it is necessary to proceed from the urgent problem of saving energy resources, preserving the environment and reducing the cost of steel production.

REFERENCES

1. Samadov A.U. "An integrated approach to the processing of technogenic formations of mining and metallurgical industries." // Tashkent. Fan va tekhnologiyalar. 2019 - p. 188.
2. Samadov AU, Yakubov MM, Khudoyarov SR, Sanakulov U.K., Zhuraev N. “Investigation of the process of processing waste containing precious metals” // Composite materials. - Tashkent, 2013. - No. 2. - S. 36-38.
3. Suleimanov A.A., Khalikulov U.M. Analysis of factors that form safety threats in the process of recycling waste gases for heating raw materials // Gorny Vestnik of Uzbekistan. 2019. - No. 4. - S. 81-86.
4. Suleimanov A.A. Review of the monograph "Technology for the treatment and disposal of oil waste using local sorbents". Monograph by S.S.Shomansurov - Saarbrücken, - S. 3-7.
5. Khalikulov U. M., Saidova K. A. Study of filtration processes with colmetation of the vapor space. Materials of the Republican Scientific and Technical Conference "Mining and Metallurgical Complex: Achievements, Problems and Prospects for Innovative Development" - Navoi, 2016. - pp. 115-116.
6. Fett, F .; Pfeifer, H .; Siegert, H .: Energetische Untersuchung eines.

Hochleistungslichtbogenofens. Stahl und Eisen 102 (1982) P. 461-465.

7. Brod, H .; Kempkens, F .; Strohschein, H: Energieruckgewinnung aus einem UHP-Elektrolichtbogenofen. Stahl und Eisen 109 (1989) 5, P. 229-238.
8. Kiselev A.D., Tuluevsky Yu.N., Zinurov I.Yu .: Improving the efficiency of gas removal of arc steel furnaces. M .: Metallurgy 1992 .-- S. 11-12.