UTILIZATION OF THE PHYSICAL HEAT OF THE WASTE GASES FROM THE STEEL ARC FURNACE (ASF)

U. M. Halikulov
Senior Teacher, Departments "Technology mountain
Metallurgical Processes" Almalyk branch of NUST

Abstract

This article analyses the risk features of pre-heating raw materials with waste gases during melting processes of steel-smelting furnace. Peculiarities are shred out of a number of characteristics and criteria of raw materials of furnace structure and technologies implemented in particle board and arc-furnace plants.
Keywords: electric steel smelting plant, hot briquetted iron, charge composition, high temperature, risks on industrial facilities, dangerous factors safety, mechanisms and methods of safety, JSC "Uzmetkombinat.

Introduction

The trend of increasing demand for steel production products obliges to increase the capacity of the domestic steel production industry, where the main role is played by JSC "Uzmetkombinat" located in the city of Bekabad of Tashkent region.

Due to structural changes and a significant change in the approach to the production cycle, JSC "Uzmetkombinat" managed to increase its production more than one and a half times and according to forecasts in 2019 the volume of production of grade-rolled products will be more than 1 million tons.

It should be noted that the main furnace of the electric steel melting shop (ESMS) of JSC "Uzmetkombinat" is an arc steel furnace (ASF) with capacity of 100 tons.

At the same time, the production itself with increased production capacity is carried out without significant replacements of the main units used for smelting. For example, with increased capacities, smelting of steel is carried out in a single furnace.

Structural and technological features of arc electric furnace make it an extremely mobile melting unit, allowing using various schedules of operation: continuous, 5 days per week, 1-2 shifts a day, etc.

In terms of the nature of the raw materials used, JSC "Uzmetkombinat" has not been uniform recently, as previously prior to structural transformation mainly metal scrap and carbon steel waste were used, and now with increased capacities it is used together with metal scrap and hot briquetted iron (HBI) waste. Accordingly, the standards and requirements for the gas-cleaning system of the ESP change due to the chemical composition of the released gases in the process of melting.

Calculation of charge by elements is carried out taking into account production of the whole charge in metal by melting: during the blow down period at least 0.30% of carbon must be oxidized; Ni, Mo - for medium cooking content; Other elements - to the lower limit; Scrap angle is 7% of the total weight of the brew.

Composition of charge at remelting by method of complete oxidation:

- carbonaceous scrap (alloy-free scrap);
- ferroalloys;
- crushed electrodes.

The practical turn to electrometallurgical technologies of steel production, and their development are connected with the emergence of additional problems of energy and environmental nature. Large-volume arc steel furnaces, which have become increasingly common in recent years, have a capacity of more than 100 tonnes and a capacity of up to 100 tonnes per hour or more. Preference for such furnaces is given to the production of steel duplex by a process where the intermediate is melted from scrap metal in the ASF and the subsequent alloying is carried out in an Integrated Steel Treatment Unit. As a result of the continuous improvement of steel smelting technology in arc furnaces, there have been significant changes in their performance. In recent years, the mass of smelts produced by large-scale ASF has increased from 86 to 110 tons, the melting time has decreased from 105 to 60-70 minutes, the power of transformers has increased from 60 to 80 MV-A, the electrode consumption has decreased from 2.9 to 1.9 kg/t, and the specific electricity consumption has decreased from 450 to 300-320 kWh/t.

The relationship between energy output and environmental performance is clear. This points to the need to identify significant energy-environmental indicators and, based on them, to improve methods of gas removal and purification, as well as to the need to identify and take into account them in the design of gas purification systems. In connection with these factors, the issue of improving the exhaust, afterburning and cleaning systems of large-volume arc steel furnaces is naturally formed, aimed at increasing their energy-ecological efficiency, reducing the volume of gases to be cleaned and reducing the emissions of pollutants into the atmospheric air.

Domestic metallurgy faces the following challenges:

- identification of the level of impact of dangerous factors on human activity;
- improving methods for calculating and estimating gas emissions from particle boards;
- study of process gas afterburning conditions of particle boards and optimization of modes of their afterburning and cooling units operation;
- finding ways to increase efficiency of discharge and purification of particle boards gases with reduction of energy consumption for purification;
- development of scientifically based recommendations to ensure the safety of particle boards.

It should be noted that the component composition of the pollutants which are thrown out by large-capacity chipboards has to be significantly expanded at the expense of such ingredients as cyanides, carbon (soot), vapors of oils and also highly toxic pollutants - benzpyrene, dioxine and furan. It has been shown that despite the small mass share of supertoxic pollutants (benzpyrene, dioxins and furans) in ARS, their contribution to environmental pollution is significant, which requires measures to reduce them.

Theoretical and experimental studies in laboratory conditions as close as possible to the conditions of the electric steel smelting shop of JSC "Uzmetkombinat" have made it possible to improve the method of gas release calculation, taking into account the specifics of gas release in the ARS both in the working space of the furnace and in their afterburning at the outlet of the furnace. The studies made it possible to assess the impact of the process characteristics of the ARS operation on the gas release process and to improve the reliability of the gas purification system design.

Practice shows that the installation behind CPD of cleaning systems using bag filters reliably and effectively solves the problem of cleaning gases from dust and partly from condensate (including benzpyrene, cyanides and some fluorides, dioxins and furans). The formation at high temperatures of other gaseous harmful substances (nitrogen oxides, persistent organic pollutants (POPs), including dioxins and furans) and their emissions depend heavily on the temperature regime and oxidation potential of gases in the furnace atmosphere and along the gas removal path. The carbon monoxide content of the exhaust gases, which is not very difficult to detect, is a reasonably reliable indirect indicator of the presence of various organic compounds therein.

The proposed method of improving the afterburning and cooling conditions of process gases can reduce the total volume of gases to be cleaned, and therefore the energy costs of their transportation and capital costs for the construction of treatment plants, as well as contribute to a significant reduction of emissions of persistent organic pollutants, the most toxic of which are dioxins and furans. Despite the huge amounts of gases supplied for purification, the issues of efficient afterburning and cooling of process gases of modern ASF have not been solved. At the same time, the basis for solving the environmental problem of ASF is complete destruction of dioxins in the zone of high-temperature afterburning of gases. At the same time, the conditions of efficient operation of the systems of evaporative cooling of gases have been estimated, which allow to reduce the volume of gases to be cleaned by several times, and therefore the energy costs for their transportation and capital costs for the construction of treatment facilities. The solution to the problem of efficient afterburning and cooling of process gases is their high-temperature afterburning followed by evaporative cooling.

A significant portion of the energy (up to 20%) introduced into the furnace is lost with off-gases, corresponding to power losses of up to 200 kw/t. These energy losses are made up of the physical heat of the gases (50-65 kw/t) and the chemical heat that can be released by their afterburning (oxidation of carbon monoxide and hydrogen). Afterburning of process gases in working space of furnace is aimed at improvement of energy balance of melting and increase of furnace productivity. This method of melting intensification was essentially a continuation of the development of another technological element - slag foaming, in which a large amount of CO is released. The efficiency of afterburning systems is characterized mainly by two parameters: the degree of afterburning of CO and the efficiency of heat transfer (ratio of afterburning energy, transferred bath and charge, to theoretical afterburning energy). Typically, the degree of afterburning is 60-100% and the heat transfer efficiency is 60%. The resulting efficiency is 35-65%. The maximum energy savings achieved during the afterburning of process gases amounted to 60 kWh/t during operation of the ASF with a capacity of 100 tons of the mini-plant "Huta Czestochowa" (Poland).

However, it should be noted that it is not necessary to adjust the degree of CO afterburning in the furnace working space to 100%, since in this case the content of nitrogen oxides (NOx) in the exhaust gases is increased, the wear of the lining and the lateral consumption of the electrodes are increased, the probability of the wall panels being run-off is increased, and the yield of useful iron oxides with process gases is decreased as a result of large carry-over. Developed in NITU "MISiS" vortex radiation injector with metal water-cooled diffuser for production of fan flame, afterburning CO near the roof surface allowed reducing electric power consumption for melting by 20-34 kw/t (4-6%) without marked increase of NOx concentration.

The fuel and oxygen consumed in the burners partially replace the electricity required. The number of burners varies from 1 to 9. Specific power - up to 200 kw/t. The total capacity for electric furnaces with a capacity of up to 50 tons is up to 10 MW, from 50 to 120 tons - 10-20 MW and from 120 to 150 tons - 20-25 MW. The operation time of TCG is about 15-20 minutes. With properly organized oxygen-gas blowing it is possible to reduce dust formation, reduce the angle of alloying elements and increase the yield. Therefore, oxygen-gas blowing, along with reducing atmospheric pollution, allows for a significant economic effect. Approximately, the introduction of modern oxygen-gas technology in the conditions of ASF (capacity 100 tons), according to experts, allowed to reduce the specific consumption of electricity by 40 kw/t.

Increasing the carbon content of the charge, as well as using TCG, is an effective way to accelerate the electric smelting. The use of iron ore concentrate powders in the oxygen stream leads to a reduction of dust content in the exhaust gases by 4-8 times compared to its content during oxygen blowing. The yield increases by 2.5%. The same effect is followed to the end by slag foaming, which is carried out by injecting the melting of powdered carbon to more efficiently transfer energy and protect the water-cooled panels from radiation. For example, with the purpose of energy saving in mine furnaces of JSC “Severstal”, slag is foamed with ground coke blown in the furnace in an amount of up to 11.6 kg/t by means of injectors. Operation of furnaces on expanded slag, heating of scrap in furnace shaft, optimization of electric mode of melting and optimization of TCG operation made it possible to significantly reduce power consumption of furnace and bring them to 269.6 kw/t.

An important requirement to ensure safety, out-of-furnace treatment is to cut off furnace slag during discharge. The first step in simplifying and improving the reliability of the slag cut-off was to use a so-called siphon outlet, i.e. to place the furnace outlet below the molten bath level. The next step was the method of bottom central and then out-of-center (oriel) output. Bath mixing in arc furnaces is used to accelerate slag and scrap melting, average bath temperature and composition, activate the slag-metal reaction in the low-temperature melt zone, and deazotation reaction of steel. Mixing is carried out by bottom injection of argon or nitrogen. At the same time the productivity of furnaces is increased by 3-6%, the consumption of electric power on refractory is reduced by 10%. The next stage of melting intensification will be injection into the bath through special tuyeres installed in the bottom, a mixture of oxygen, coke, coal, lime. Intensification of bath mixing process leads to reduction of reaction zone temperature and reduction of dust formation intensity. Therefore, feeding argon into the bath to intensify mixing brings to the reduction of dust formation and shrinkage of the waste of the alloying agents.

Not only the quality of the metal charge, but also the way it is loaded into the furnace significantly affected the environmental characteristics of the ASF. The use of continuous charge loading is not only one of the effective ways to increase the intensification of metallurgical processes in the ASF, but also an effective method of improving environmental indicators. With occasional loading of, for example, steel furnace charge materials, the volume of unorganized gas flow increases dramatically and uncontrolled, which is practically impossible to remove or clean and use in a controlled manner.

Conclusion:

Improving the quality of scrap and heating it appears to be one of the effective ways to improve the energy-environmental indicators of ASF. In order to save energy resources, the technological use of heat of furnace exhaust gases, which form a significant part of the thermal balance of the electric furnace (more than 19-25%), seems very tempting. The technology of electric steel smelting with preliminary heating of scrap allows creating super-heavy ASF in their most expected variant in the future - without fuel use.

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