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The Compute Research of Mode Parameters Influence on the Furnace Heat Work in Vanyukov's Smelting Energotechnological Complex

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The influence of furnace operating conditions on the heat transfer in Vanyukov's smelting energotechnological complex has been researched on the basis of its polyzonal mathematical model. The quantitative relations have been found allowing to run the melt more effectively to maintain melting temperature required by the technology when composition of matte being constant. The recommendations for efficient operation mode of lining cooling under layer space of the furnace were given.

Keywords: energotechnological complex, the smelting in the liquid bath, Vanyukov's furnace, heat transfer mathematical model, operating conditions.

Introduction

The wide application of the melt in the liquid bath (Vanyukov's smelting) in Russian non-ferrous industry connected with following advantages of the process: the possibility of lump and secondary raw material recycling; high specific furnace productivity; low furnace dust; the wide range of unit capasity. In spite of research fullness of physicochemical basics of barbotage bath melt the thermalphysic features of processes taking place in energotechnological complex «Vanyukov's furnace – waste-heat boiler» (VS ETC) have been explored less. That does not allow to design effective complex structure, to maintain effective and durable work of entire VS ETC and create means and methods for its operation.

In particular, questions of mutual influence on heat exchange indexes of the processes taking place in melt bath, in over layer (gas) furnace space (GS) and work volume of waste-heat boiler (WHB) has still no answer. For example, change of input parameters of furnace work leads to alteration of technological gases temperature before WHB. Determination of this temperature gives the opportunity to forecast WHB output technological gases temperature.

This paper presents calculation research results of VS ETC operating conditions influence on GS thermal condition: coordinated alteration of concentrate load (furnace productivity) and technological oxygen consumption, melt bath temperature (consumption of coal and blast) and lining cooling

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intensity (water temperature over drop in jackets). These parameters variation allows to operate melt technology more effectively to maintain required molten metal temperature (1250…1350 °C) under condition of the matte composition constancy.

Experimental

The research has been conducted on the basis of previously developed three-dimensional mathematical polyzonal model of heat exchange in VS ETC, which equation system takes into account heat and mass exchange between GS and WHB, their geometrical features, lining cooling system presence, flammable compounds combustion [1]. There were made a range of improvements to make the mathematical model closer to the real melting processes in VS ETC.

When modeling heat and mass exchange in VS ETC the attention was paid to the fact that intensive melt barbotage results in high spattering consequently spattering drop out of the furnace. The carry-over is in a liquid state and has high temperature that can essentially act on heat exchange volumes in GS. Aggressive carry-over under high temperatures promotes increased lining wear out and WHB heating surfaces soiling and slagging. Therefore to connect WHB, GS and melt baths into one ETC the zone equation system additionally considers hard and liquid skull formation on bath enclosures and gassing and spattering from the melt bath as well [2, 3]. In addition, when calculating radiation heat exchange the model has taken into account selective character and radiation dispersion by gas and dust [4].

Results and discussion

The design- theoretical analysis of heat exchange processes was made on the Balhashski MMC industry VS ETC example. The operating conditions of ETC have been taken accordingly furnace # 1 balance tests (VS-1). In the basic variant relatively to the project one the charge input was G_o = 19.44 kg/s, where 15.3 kg/s were put through load windows at the melting side. The melt bath temperature was t_m = 1350 °C, the gassing power was ν_o = 8,53 m^3/s. It was considered that gassing and spattering from the melt went evenly on the whole bath surface except ones under load windows. The proportion

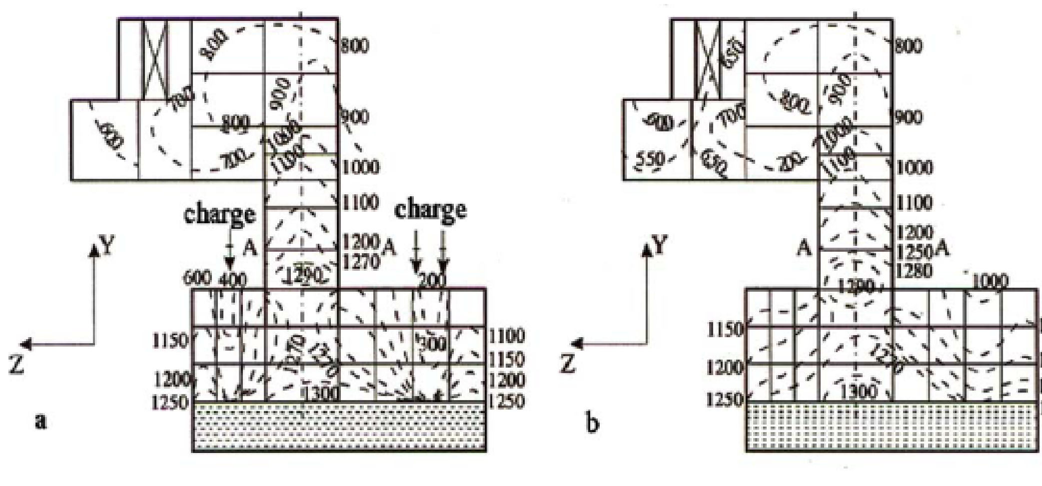

Fig. 1. Gas and dust environment temperature distribution in VS ETC, °C: a – central layers; b – layers near the walls

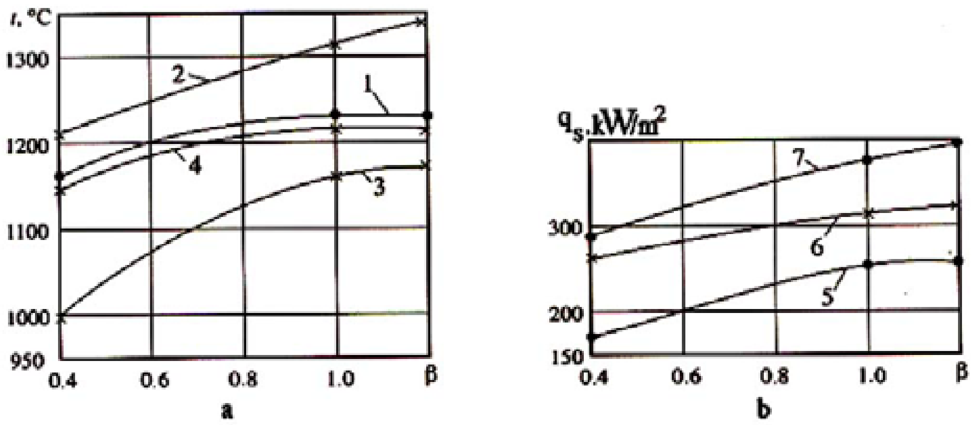

Fig. 2. The influence of relative charge consumption β on heat transfer indices in GS VS: a – temperatures: 1 – for gases going out of the furnace; 2, 3 and 4 –maximums for gas, furnace roof arch surface and uptake; b – maximum density of falling radiation streams: 5, 6 and 7 – on the furnace roof arch, walls and uptake (G = 19.44 кg/s)

of circulating technological gases in GS were as follows %: 40.5 SO_2; 2.1 CO_2; 14.2 H_2O; 3.2 O_2 и 40.0 N_2. Calculation results when no dust flue combustion in uptake are shown in the Fig. 1.

1. *Charge and oxygen consumption.* Comparison analysis of three variants of furnace operating conditions has been made. In addition to the basic variant there were calculated two more: the first one with increase of charge on 20 % (G_1 = 23.33 kg/s) and technological oxygen, that corresponded to gassing rate ν_1 = 10.233 m^3/s and calculated melt bath temperature t_m =1378 °C, the second one with decrease of charge on 60 % (G_2 = 7.78 kg/s) and technological oxygen, that corresponded to ν_2 = 3.411 m^3/s and t_m = 1266 °C. In both variants of t_m volume has been calculated from condition that when coordinated changing of load and technological oxygen consumption the melting temperature sensitivity coefficient S_T = dT/dG was 2 K/ton of charge.

The analysis shows that the load acts mostly on the heat streams temperature in lower layers of GS joined to the melt bath. So when changing relative load (productivity) $\beta = G_i / G_o$ in range from 1.0 to 1.2 the gases temperature on the first sector (x = 0…2.4 m) increases in I-IV (uptake) layers on 25…6 °C. The Fig. 2 shows that basic heat exchange data vary more greatly when the furnace less loaded corresponding to β = 0.4…0.8.

2. *Melt bath temperature.* Melt bath temperature t_m is highly sensitive to the input parameters stated above and especially to coal consumption. So when coordinated coal consumption and technological oxygen changing the coefficient S_T reaches to 120 K/ton of charge. Therefore the research of t_m influence on thermal GS condition is of great interest. For this purpose, there were additionally calculated third and fourth variants, where t_m was equal to 1250 and 1400 °C accordingly. Blast and charge consumption, structure and volume of technological gasses were as in the basic variant where t_m = 1350 °C.

The analysis shows that the bath temperature level almost does not change distribution of temperatures and heat streams in GS volume. Moreover, the melt temperature influences mostly on temperature level of heat streams in lower parts of the furnace near the bath surface and less in higher parts of the furnace near roof arch and uptake. The t_m alteration on 1K in the range from 1250 to 1350 °C leads to the same temperature change of gasses going out of the furnace t_o on 0.84 °C, falling radiation streams maximum density q_s^{max} of arch change on 0.68 kW/m^2, falling radiation streams maximum

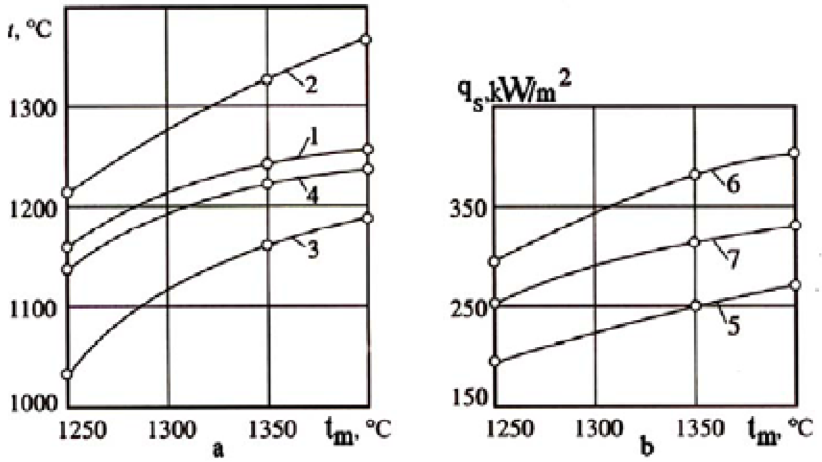

Fig. 3. The melt bath temperature influence on the heat exchange indices in GS VS: a – temperatures: 1 – for gasses going out of the furnace; 2, 3 и 4 – maximums for gas, furnace roof arch surface and uptake; b – maximum density of falling radiation streams: 5, 6 и 7 – on the furnace roof arch, uptake and walls

density q_s^{max} of walls change on 0.92 kW/m²; in the range from 1350 to 1400 °C these indices change accordingly on 0.28 °C, 0.34 kW/m² and 0.78 kW/m² (Fig. 3). The melt temperature change by means of coordinated alteration of coal consumption and blast has a greater influence on GS heat exchange when melt bath has low temperature.

3. The lining cooling conditions. Analysis of GS VS heat exchange with shifted uptake has shown that under uniform specific heat extraction from jacked bounding furnace surfaces q_w there is an uneven distribution of temperatures and heat streams. For example, in the basic variant the maximum temperature over drop on the side walls is 260 °C and q_s – 200 kW/m². For this reason, the influence estimation of heat extraction intensity on heat work conditions of GS jacked surfaces is of great interest. There were made calculations, where furnace GS lining heat extraction integral volume Q_w changed from 0 to 2000 kW. According to the calculations, the Q_w increase on 100 kW leads to decrease of maximum temperatures of gasses and GS walls in average on 6 and 9 K, t_o – on 5 K. So when Q_w = 1000…1500 kW the moderate maximums of temperatures of GS side walls (on the level 1200…1250 °C) could be achieved.

Conclusions

Using improved polyzonal mathematical model there was researched the influence of input furnace operating conditions on heat exchange in ETC. Parametric analysis shows that:

– charge and oxygen consumptions mostly influence on temperatures and heat streams levels near melt bath especially when small charges take place: 10 % change of furnace charge capacity alters the maximum density of falling on wall radiation flows on 19 kW/m² and technological gasses temperature before WHB on 14 °C;

– consumption of coal and oxygen (temperature of melt bath) almost does not alter the character of temperature and thermal fields in volume of GS and mostly influences on their level near melt bath (especially when low warming up);

– there is significant irregularity of temperature and heat flow distribution when uniform specific heat extraction from jacked furnace walls;

– durable work of GS lining can be achieved when integral value of heat extraction is no less than 1.0 MW taking into account rational distribution of specific heat extraction value in different zones determined from values of falling radiation streams calculated in advance.

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Расчетное исследование влияния режимных параметров на тепловую работу печи энерготехнологического комплекса плавки Ванюкова

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На основе многозональной математической модели изучено влияние режимных параметров работы печи на теплообмен в энерготехнологическом комплексе плавки Ванюкова. Установлены количественные зависимости, позволяющие наиболее эффективно управлять процессом плавки с целью поддержания требуемой по технологии температуры расплава при условии постоянства состава штейна. Даны рекомендации по рациональному режиму охлаждения футеровки надслоевого пространства печи.

Ключевые слова: энерготехнологический комплекс, плавка в жидкой ванне, печь Ванюкова, математическая модель теплообмена, режимные параметры.

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