Analysis Of The Characteristics Of The Blast Furnace Peripheral Zone.

S.O. Jimoh. C.B. Pyhteeva, S.A. Zagaynov

Abstract: It is known that the minimum flow of coke rate is reached when CO use is at a maximum in the blast furnace. This is achieved when the peripheral zone carries the furnace's maximum permissible load and is operating with an open center. An overloaded in the circumference leads to an increase in the FeO content of the primary residue, which is not conducive for the creation of steady-state soot in the furnace waist and shoulders. This leads not only to an increase in heat loss, but also accelerates the wearing of the lining. The purpose of this research was to study the characteristics of heat emissions and recovery work in the peripheral zone of the blast furnace. Modern feeders allow you to distribute charge so as to achieve maximum degree of reduction potential of the gas stream. However, there were risks associated sustainability in the skull and shoulders thrust. Therefore the development of measures to ensure the operation of peripheral zone of the blast furnace, is an urgent task. The developed model to calculate the gas temperature and its recovery in the peripheral zone of the blast furnace can be used to optimize the thermal state of the shaft furnace in the peripheral zone.

Keywords: Blast-furnace, coke rate, carbon monoxide, heat-loss, iron oxide, peripheral zone, primary residue, lining.

1 Introduction

Recovery work of the gas flow in the blast furnace can be viewed through the increase in the indirect restoration of iron oxide, which is estimated by the degree of indirect regeneration, calculated according to the equation [2].

$$R_i = \frac{0.01\, V_g\, [(CO + CO_2)\, x\, \eta_{co} + (H_2 + H_20)\, \eta_{H2}]}{2P\delta} \quad - \quad (1)$$

Where:

V_g - Furnace gas output per unit time

CO, $C0_2$, H_2 and H_2O are contents of the congruent component in the blast furnace gas in %;

η_{co} *and* η_{H2} is the utilization of CO and H_2 (respectively);

P is the efficiency of blast furnace per unit time;

δ is the unit quantity (at 1t. of cast Iron) of gasified oxygen.

- Engr. Sumaila O. Jimoh, Phd (Scholar)
- Prof. S.A. Zagaynov, Head of Department. Ural Federal University named after the first President of Russia Boris Yeltsin, Yekaterinburg. Department of Metallurgy of iron and Alloys. Institute of Material Studies and Metallurgy.
- Email: smaila20002001@yahoo.co.uk
- Mobile: +79505601069

2. Blast Furnace Peripheral Zone

Other things being equal, the utilization of CO depends on the amount of time the furnace charge remains in the indirect reduction zone. It is widely accepted that most of the reduction reactions in the blast furnace do not reach equilibrium. The effect of the recovery time on fluctuations in equilibrium observed in the concentration of the reactants is expressed by the speed of reaction [1].

$$v = \frac{dx}{d\tau} = K\left(x - x_p\right) - \quad - -(2)$$

Where:

v - Rate of the chemical reaction, mol/l.s

x – The concentration of the substance

x_p - Equilibrium concentration, mol/ℓ

τ – Time in Seconds; K – reaction rate constant

The integration of the given expression allows for the determination of fluctuation levels in the concentration of the body relative to the time of reaction flow:

$$\int_{x_p}^{x} \frac{dx}{x - x_p} = K \int_0^{\tau} d\tau - \quad - -(3)$$

$$\ell n\left(x - x_p\right) = k\tau$$

or

$$x - x_p = e^{k\tau} \quad - \quad - -(4)$$

The relationship between the amount of used carbon monoxide and time is expressed by the equation:

$$\eta_{co} = \eta_{co}{}^{p}\ (1 - e^{k\tau}) \quad - \quad (5)$$

where

$\eta_{co}{}^{p}$ is equilibrium utilization of carbon monoxide

T– time used by body in the reduction zone.

Otherwise, after linearization:

$$\frac{\Delta\eta_{CO}}{\eta_{CO}} = \frac{\Delta\eta_{CO}}{\eta_{CO}} - \frac{e^{k\tau}}{1-e^{k\tau}} \mathrm{P}\,(k\Delta\tau + \Delta k\,\tau) \text{ ---} \quad (6)$$

Given a steady reaction speed constant in the area of operating modes, the equation becomes:

$$\frac{\Delta\,\eta_{CO}}{\eta_{CO}} = \frac{\Delta\eta_{CO}}{\eta_{CO}} - \frac{e^{k}\mathrm{P}}{1-e^{k\tau}} \quad \Delta\tau \text{ -} \quad (7)$$

P

The first component allows us to determine the impact of indirect regeneration of thermodynamic factors and the kinetic factors on the progress of reaction. Time is determined by the height of the area [3].

$$\tau = \frac{24 \times \delta \times H}{P\ \gamma_{sp}\ (1-f)} \text{ - -} \quad (8)$$

Where d

S - Is the cross-section of the ring, which is located on the periphery, m^2;

H - Is the height of the heat transfer top step, m;

P_d - Daily Performance, ton of P is Don per day

γsp – Specific volume of the material, m^3/ton of pie iron

f - Is the charge settling coefficient expressed as a decimal fraction.

$$H = \frac{3.w_{ch}.C_{ap}.\rho_{ch}}{\alpha_v.(1-m)} \text{ -} \quad (9)$$

Where:

W_{ch} – Stock descent speed, m/s

C_{ap} – Apparent heat capacity, kJ/kg.k

ρ_{ch} – Bulk density of the charge, kg/m^3

α_v – Coefficient of heat transfer W/m^{3}K

m – Ratio of specific heat of the charge to the gases

The relationship between the gas velocity and pressure drop is calculated by Ergun's equation [5].

$$\Delta P = \lambda.\frac{h}{d_э}.\frac{1-\varepsilon}{\varepsilon^3}.\frac{T}{T_0}.\frac{P_0}{T}.\frac{P_0 \times W_0^2}{2} \text{ - -- - -} \quad (10)$$

Where:

λ – Resistance factor

$d_э$ – Reciprocal diameter of the blocks of layers, m

ε – Porosity of layer, m^3

T – Temperature, k

P – Pressure

P_0 – Gas density, kg/m^3

W_0 – Speed of the gas the subscript "o" denotes the size in normal conditions.

The porosity of the upper layer of the furnace could be determined using the equation

$$\varepsilon = \frac{P_H\ x\frac{\varepsilon ore}{\rho ore} + \frac{\varepsilon c}{\rho c}}{P_H\ x\frac{1}{\rho ore} + \frac{1}{\rho c}} \text{ - -} \quad (11)$$

Where:

P_H – ore load $^{ton}/_{ton}$

E_{ore} and E_c – Porosity of the ore and coke constituent, respectively

ρ_{ore} and ρ_c – Bulk density of the ore and coke constituent, respectively ^{ton}/m^3.

In order to calculate the temperature of the peripheral top smoke, equations (1) (7-11) are solved simultaneously with the well-known heat exchange equations [4].

$$m = 0.5\ (\ 1 + \frac{C_{ch}\ xG_{ch}}{C_g.V_g})\text{ - -} \quad (12)$$

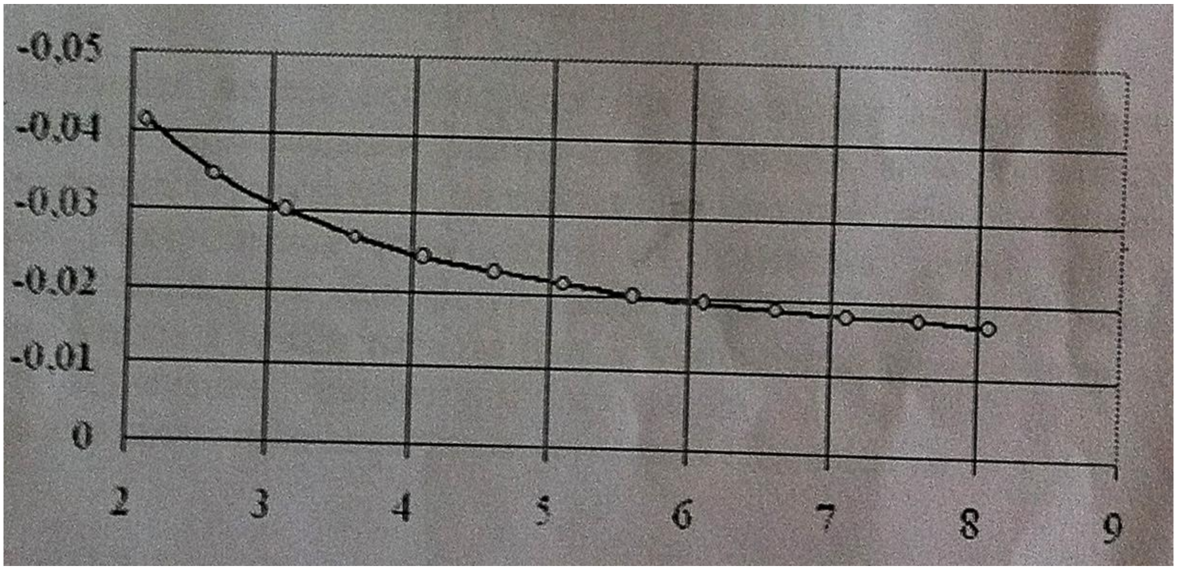
$$m = \frac{t_0 - t_{ic}}{t_{ro} - t_{ch}}\text{ - ---------} \quad (13)$$

$$\Delta m = -\ (m - 0.5)\ x\ (\frac{\Delta(C_{ch}\ xG_{ch})}{C_{ch}xG_{ch}} - \frac{\Delta(C_g\ xV_g)}{C_g xV_g})\text{ ----} \quad (14)$$

$$\Delta\ t_G = \Delta m\ (t_{sho} - t_{shk})\text{ ---- -- -} \quad (15)$$

The results of the estimation with the use of the developed method when the ore load increases to 0.1 depending on its size are shown in Figures 1 and 2.

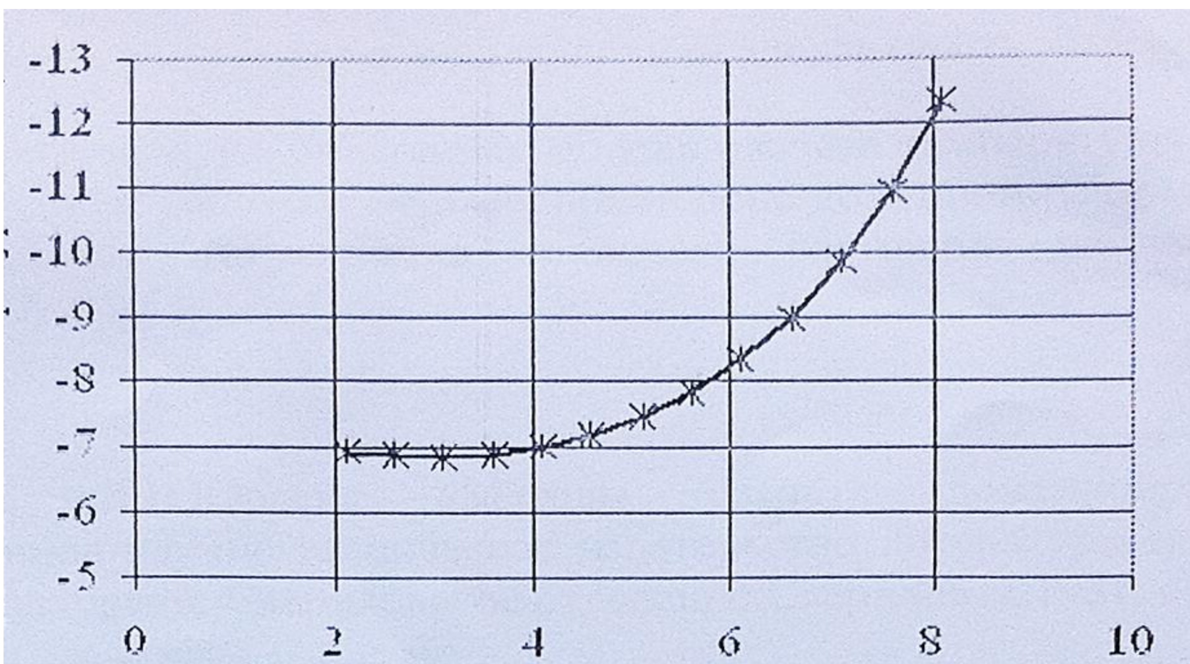
Change degree of indirect regeneration



Ore load, T/T

Fig. 1 Change in the level of indirect regeneration at the increase of ore load to 0.1

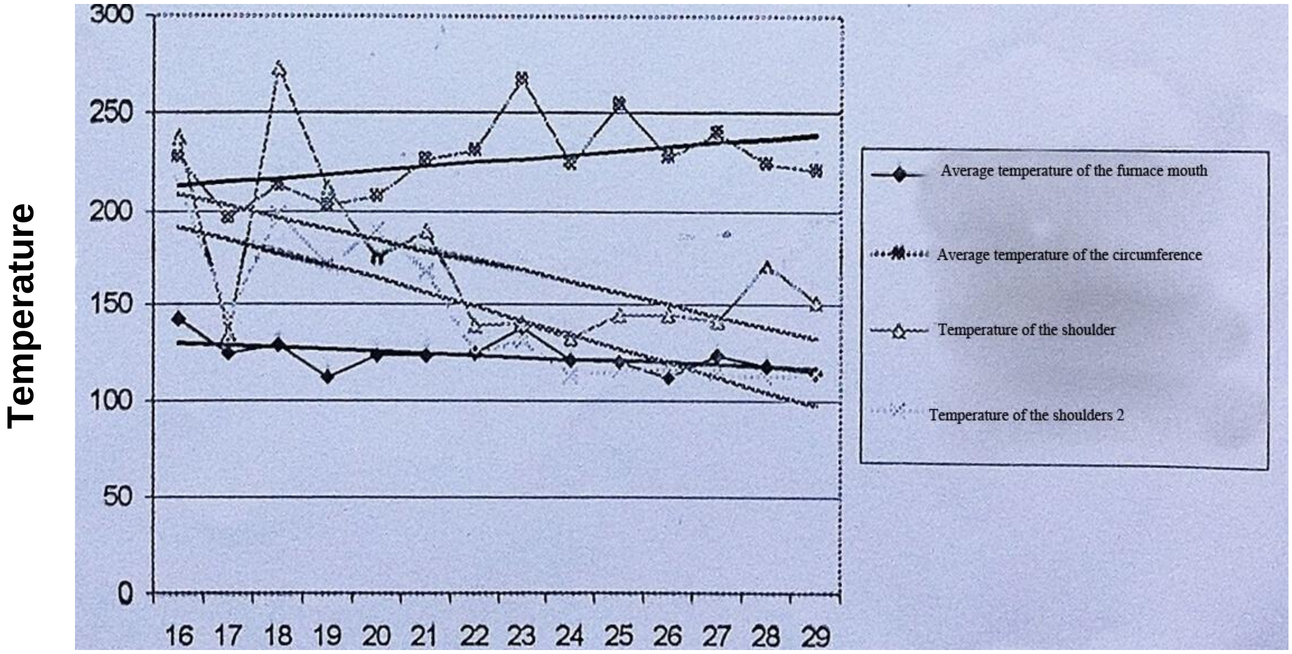
Change gas temperature, ^0C



re load, T/T

Fig 2 Change in temperature of peripheral gases when ore load is increased to 0.1

The developed model is used to generate quantitative recommendations for the normalization of the peripheral zone. Given as an example are results of the use of models for the elimination of a disorder of the peripheral zone of a blast furnace "EVRAZ NTMK." With the shoulders kept at high temperatures and peripheral gas kept at a lower temperature at the beginning of the period (Fig. 3), the ore load was reduced to 0.3 t / t. The change in temperature of the circumference was +20 ° C while the temperature of the refrigerating shoulders dropped by more than 50 ° C [6].



December, 2009

Figure 3 Blast furnace instrumentation data

Industrial data confirmed the adequacy of the model.

3 Conclusions

Thus, the decision of the equation of heat exchange, mass exchange and reduction in conditions of the developed model to calculate the gas temperature and its recovery in the peripheral zone of the blast furnace can be used to optimize the thermal state of the shaft furnace in the peripheral zone.

References

[1]. B.I. Yurev, L.V. Yureva Methods for calculating the blast furnace. State Scientific and Technical Publishing House of Literature on Ferrous and Non-Ferrous Metallurgy. Sverdlovsk. 1961. Page 211.

[2]. V.B. Semokova, V.V. Semakov, D.Y. Gavriloglu. Azov State Technical University (Mariupol, Ukraine). Analysis of the efficiency of the recovery processes in blast furnaces. ‘Steel’№ 4 2012. p.4-5.

[3]. S.V. Shavrin et al. Calculation of the Degree of Heat Transfer in Blast Furnaces. 1960. Number 11. Pages 27-31.

[4]. B.I.Kitaev et al. Heat Transfer In A Blast Furnace. Edited by Professor B.I. Kitaev. Publishing House "Metallurgy". Moscow 1966. Page 288-293; Pages13-114.

[5]. V.Y.Gubinsky et al. The Metallurgical Furnace. Theory and Calculations. Volume 2 edited by Professor. V.I. Tymoshtyulskiy, Dr. V.I. Gubinskogo. Minsk. "Belarusian Science" 2007. Pages 270-277.

[6]. C.B. Pyhteeva. Improving the loading system of blast furnace with production of titan-magnetite. Ph.D Thesis, Ural Federal University, Yekaterainburg, 2011. Pp 136-143.

[7]. Jimoh, S.O., Ibrahim, M.E. and Ighalo B.S.O. (Sept.2008) Determination of optimum lump size of sinter obtained from itakpe iron ore concentrate as charge material for blast furnace. “Nigeria Journal of Engineering in faculty of Engineering, Ahmed Bello University, Zaira, Nigeria. Vol. 14 No.2 Pp. 5-7.

[8]. Guleva, L.U., Zagaynov, S.A. (2011) Balancing method of calculating metallurgy of iron making processes. Ural Federal University, Yekaterainburg, P 72.