THE DECREASING OF THE ENERGETIC LOSSES AT A COKE DRY COOLING PLANT

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ABSTRACT

The paper presents an energetic and technologic analysis of the metallurgic coke dry cooling plant (CDCPO) operating, and also the optimization of this process in the case of an industrial plant, existing in the Steel Works S.A. Galati. The drawn–up analysis is based on the thermal balance of the industrial plant, in order to establish some mathematical equations that characterize the technological process.

KEYWORDS: coke, thermal flux, recuperation boiler, mathematical model

1. Introduction

The efficiently of (ISUC – Cooke Dry Cooling Plant) from "MITTAL STEEL SA" is made by using the thermal balance of this installation.

This means, that proper establish a mathematical model that characterize a good functionary for (ISUC) based on entrance system parameters.

2. This installation is used on a coke cooling (I.S.U.C.)

This installation is used on a coke cooling by using inert gases and warm recuperation with recuperation boiler. This plant has five blocks. Each block have: an extinction recipient, a recuperation boiler, a principally exhausting and systems for powder elimination and too a system for measuring and automation of functionary parameters (fig. 1).

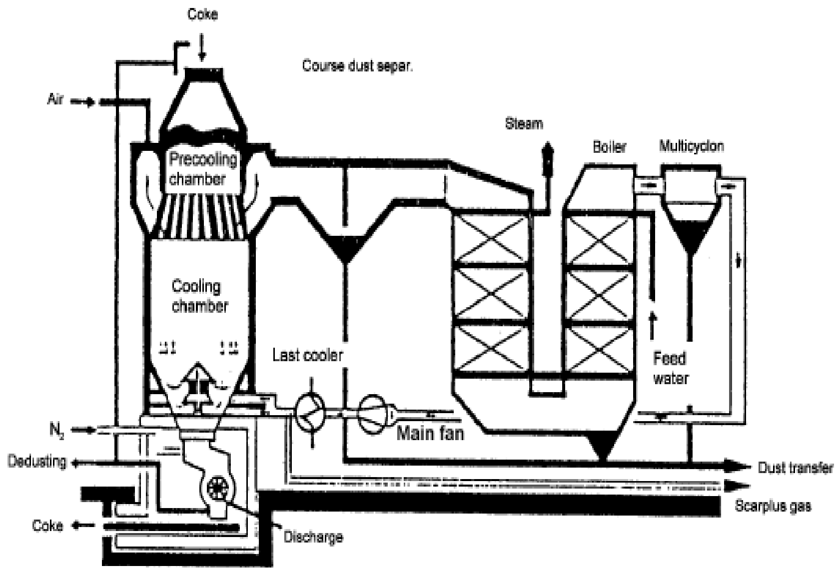

Fig 1. *Coke Dry Quenching Installation.*

The extinction recipient has two compartments (extinction recipient and a room for warming cocks accumulation) and at the bottom an installation for gases distribution and a hole for cooling coke evacuation. At the top there are channels for gasses accumulated finishing with a hole for inert gases evacuation. The charging of warning coke in a mechanized operation on the top of installation and than is mode an hydraulic entrance opening.

The inert gases are sender in continuous system throw inellary hole in layer of warning coke. At 800^{0}C this gases left the recipient and enter into recuperating boiler. The inert gases an evacuated continuously into atmosphere. The cokes get down from top to the shaft bottom and the "cold" coke at 250 – 280^{0}C.

The gases moving in installation, is made by an exhausting tip VH 160/850 with Q=160.000 m^3/h and a low pressure Δp=804x10^2 N/mm^2. The work temperature of the exhausting is 180 – 200^{0}C.

The parameters of (ISUC) installation are:

– warming coke temperature 1000 – 1050^{0}C;

– cooling coke temperature 250 – 280^{0}C;

– the temperature of moving gases before recuperation boiler: 750 – 800^{0}C;

– the temperature of moving gases before the entrance in the recipient 180 – 200^{0}C;

– the quantity of warming blow at one tone of coke 400 – 420 kg;

– the productivity of recuperating boiler is 85t/h of warning blow at the temperature of 430 – 440^{0}C.

The measuring installation has the next possibility:

– measuring the temperature of coke on the transported of installation;

– measuring the temperature of lining Y in the channels zone;

– measuring the temperature of inert gas at the entrance into the bottom of recipient;

– measuring the temperature of inert gas at the exit at the top shaft;

– measuring of the inert pressure at the entrance into the shaft (400 ÷450 · 10^2 N/mm^2);

– measuring of the coke level into the installation by radioactive sources.

3. The technology of I.S.U.C

The principally chemical reactions produced during the air moving into installation are:

a) completely oxidation of the carbon from the coke:

$$C + O_2 \rightarrow CO_2 + 409500\ kJ \quad (1)$$

$$q = (97853 - 0{,}469T + 0{,}000879T^2 + 0{,}62 \cdot 10^{-6}T^3) \cdot 4{,}1868 \quad (1.1)$$

b) incompletely oxidation of the carbon the coke:

$$2\,C + O_2 \rightarrow 2\,CO + 248700\ kJ \quad (2)$$

$$q = (60320 - 4{,}298T + 0{,}003594T^2 + 1{,}25 \cdot 10^{-6}T^3) \cdot 4{,}1868 \quad (2.1)$$

c) the reducing of water vapour from air with carbon (t≥900^{0}C) :

$$H_2O + C \rightarrow CO + H_2 - 118000\ kJ \quad (3)$$

$$q = (-26853 - 5{,}269T + 0{,}002719T^2 + 0{,}546 \cdot 10^{-6}T^3) \cdot 4{,}1868 \quad (3.1)$$

d) the reducing of water vapour with carbon (t≤900^{0}C) :

$$2\,H_2O + C \rightarrow CO_2 + 2H_2 - 74940\ kJ \quad (4)$$

$$q = (16162 - 6{,}709T + 0{,}002723T^2 + 0{,}462 \cdot 10^{-6}T^3) \cdot 4{,}1868 \quad (4.1)$$

The reaction with water vapour has been in generally at the start of installation on at the breaking of recuperating boiler, when water vapour penetration the gases circuit.

e) the methane is forming :

$$C + 2H_2 \rightarrow CH_4 + 77870\ kJ \quad (5)$$

$$q = (15713 + 11{,}351T - 0{,}00673T^2 + 2{,}182 \cdot 10^{-6}T^3) \cdot 4{,}1868 \quad (5.1)$$

f) the reducing of CO_2 at high temperature no oxygen:

$$CO_2 + C \rightarrow 2\,CO - 161000\ kJ \quad (6)$$

$$q = (-37533 - 3{,}829T + 0{,}002715T^2 + 0{,}63 \cdot 10^{-6}T^3) \cdot 4{,}1868 \quad (6.1)$$

With increasing of combustible elements has been a increase of diverse concentration whose combustible components into the moving gases are given in table 1.

***Table 1** Different functionary models of (ISUC)*

Functionary of (ISUC)	The composition of gases						Explosion boundaries		The admissible concentration
	CO	H_2	CH_4	C	CO_2	N_2	inf %	sup%	
No nitrogen	23,6	7,50	0,60	0,20	4,42	63,5	8,40	75,0	5,25
With added of nitrogen	12,6	3,84	0,60	0,20	6,04	76,8	8,30	65,0	7,35
With burned of combustible	4,92	6,06	2,62	0,36	16,0	76,2	8,20	31,0	14,10

4. Mathematical model

The analysis mode permit to appreciate the purpose of each thermal flux of (I.S.U.C.) for a energetically efficiently of this process.

The optimal regime for recuperating boiler of (ISUC) who keeping the warming blow parameters is the calculus regime for a production of 25 t/h and a productivity at 50 t/h cooling coke at gases debit of 82000 m^3N/h at a entrance temperature of gas into the recuperating boiler of 800^0C.

The primary thermal fluxes of I.S.U.C. are burning coke and sour–warm steam. The link between these two fluxes is making by flux of moving warm gas. If the energy of sour–warm steam is highly, the energy at the exit from dry cooling room is much highly and too is aspect a greatest energy at the exit of recuperation boiler and grow the efficiently of I.S.U.C. like energotechnology system.

The values of energetically losses are characteristics of coke dry cooling and can be considered like efficiently criterions.

For a optimally developing of coke dry cooling is necessary to study the efficiently criteria and to determine by measuring the total energetically looses and than to find the way increase the efficiently of I.S.U.C. The most important problem is to diminish the total energetically looses (equation 7).

It must to find the order variable of this process and than to drive in a optimal way the I.S.U.C.

$$Q_p = f(X_i) = \min \quad (7)$$

were:

X_i – technological variable; (i=1, 2, 3, , k)

The most important energetically looses is generated by a badly change of warm into – the dry cooling room, the recuperation boiler, looses of moving gas throw the aspiration smoke pipes, the temperature of gas flux at the exit of recuperation boiler and the flux of dry coke.

All looses of coke dry cooling plant are describe in the next equation:

$$Q_p = -5{,}53 + 4{,}37\cdot10^{-4}X_1 + 0{,}96\cdot10^{-4}X_2 + 0{,}61\cdot10^{-4}X_3 + 4{,}22\cdot10^{-4}X_4 + 1{,}55X_5 + 1{,}38X_6 \quad (8)$$

Equation is not valid at the boundary:

$$36000 \le X_1 \le 54000 \quad (9)$$

$$X_2 \le 160000 \quad (10)$$

$$1400 \le X_3 + X_4 \le 7000 \quad (11)$$

$$0{,}0039\cdot(X_2 + X_3 + X_4) \le 630 \quad (12)$$

$$1{,}2 \le X_5 + X_6 \le 5 \quad (13)$$

$$0{,}0324\cdot X_1 - 0{,}0176X_2 + 111\cdot X_5 + 110\,X_6 - 120 \le 250 \quad (14)$$

were:

– X_1 – the consumption of burning coke, [t/h];

– X_2 – consumption of moving cold gas, [m^3/h];

– X_3 – consumption of gas, [m^3/h];

– X_4 – consumption of gas throw aspiration smoke pipe, [m^3/h];

– X_5 – the increase of contents of CO_2 in moving gas, %;

– X_6 – the increase CO in moving gas, %.

For to know the minimal energetically looses is necessary to find the values of $X_1 \div X_6$ (technologically variables).

The efficiently criterions is a linear function and boundary equations (9) – (14) are binary, than for solving minimized problem is used the SIMPLEX method of linear programming.

The transforming of boundary equation at the canonized tip throw nearly transformation in corresponding with (9)–(14) is very complicated. For a really solving of this system of equation is used a performed computers and same algorithm for left and right zone by making 5 iteration (left) and 6 iteration (right). In table no. 2 is shown the results of this calculus.

Table 2

The tehnological variables	Left zone		Right zone	
	Optimum values	**Real values**	**Optimum values**	**Real values**
X_1	54	–	42	22
X_2	86243	69323	54750	107045
X_3	6989	–	1400	5400
X_4	1,3	3,8	–	–
X_5	–	–	1,4	4,2
X_6	27,98	–	18,23	–

5. Conclusion

The productivity of coke plant is dependent of consumption of the coke. The temperature of dry coke order variable and can be mention between two borders.

Another component of energetically looses is moving flux gas. The decrease of this component is possible by reducing the temperature of gas flux often recuperating boiler. The consumption of cold gas is conditioning by charging of coke and the asked for temperature of dry coke.

If the energy in recuperating boiler is much, the temperature of gas is low and the functionary of plant is good (efficiently). The decrease of morning gas temperature make possible reduce of energetically looses and can be assured a good transmission of alimentation water into the boiler. The looses in pipes rooms and smoke aspiration is not too much.

For to reduce the energetically looses by pipes is necessary to decrease or to close completely the room pipe and to eliminate the surplus of cold moving gas and in the same time is grow up the ecological security.

The looses resulting by the burning of coke can be reduced by diminish of oxygen aspiration from air in the channel of moving gas. The value of oxygen aspiration is dependent of: the degrees of opening of smoke aspiration pipes and the guide apparatus of smoke aspiration. The two factors are considered for regulation actions in channel.

Thus, for the effective progress of coke dry quenching process, i.e. for the reduction of the energy losses in the installation, as it results from the analysis, the following must be provided: minimum possible temperature of quenched coke, required value of the discharges in the circulation system (so as aspirations to be minimum), the minimum temperature of the circulation gas at the entry in the quenching chamber, the optimum feeding water quantity in agreement with the level of the boiler.

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