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Experimental saving of COG energy on hourly basis in coke making industries

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Abstract- The core of the steel business is the coke manufacturing facility. Coke is produced at coke oven facilities and utilised in blast furnaces as a reducing agent. Coke is a crucial ingredient that is a reducing agent. The two main uses of coke are in the production of steel and metal extraction. Coke is a key ingredient in the production of high-grade steels in an integrated steel plant. Unwanted gas emissions in coke-making operations are currently considered a severe problem by national environmental requirements. The coke production complex is a complex region where the majority of coke oven gas pollution is produced in a steel industry of the integrated type. In this research paper up to 100 Nm3/hr COG flow can be reduced by using proper chamber flue maintenance job in coke making industries. The saving of COG as energy is eco-friendly to our open environment. It also include in the coke manufacturing plant, conserving coke oven gas energy aids in lowering carbon emissions.

Keywords: Coke making industry, COG, coking coal, coke oven heating flue, chamber wall flue, coke oven plant, recovery type coke making plant

1. Introduction

The coking coal is necessary for appropriate coal carbonization throughout the coke-making process. Additionally, the coking coal needs to exhibit good caking, swelling, and plastic behaviour. Basically, the right values of the crucible soiling index were required for coking coal [1]. The final meeting of the two plastic layers should ideally be equally spaced from the top and bottom, which requires calibration of the coke manufacturing plant's hydraulic regime and air regulation. It is assumed that the passageways have been designed with enough room to allow the partially combusted flue gas to move from the oven chamber to the solitary flue without experiencing a considerable pressure reduction. The uptake passageway's design must be sufficient to provide minimal pressure drop. [2]. Two basic plastic layers are created in any type of carbonization, whether it be using standard recovery slot ovens or none/heat recovery ovens, and they move from the heating surfaces towards the core of the coal lump. When the two plastic layers converge in the middle of the coal lump, caking time is over. Technically, it is the net coking time, but the coke is ready to be pushed after adding some soaking time to get to the gross coking time [3]. In [4] this essay discusses coal heating in the absence of outside air. The solid substance that is discovered is known as metallurgical coke. In a blast furnace, coke is a crucial component for the creation of hot metal. [5]. in [6] the latter damages the silica brickwork and results in the development of clinker. The oven brickwork could suffer early damage as a result of this. However, when foul gas leaks into the heating chamber, it causes gas and by product losses, disruptions to the heating process, and frequently melting of various materials depending on the locations where this raw gas starts burning in the heating chamber. In [7] under the influence of the high temperature in the coking chamber, the process of coal carbonization and the dissociation of hydro-carbons present in the foul gas may happen. The carbon that has been thusly dissolved is deposited in any fractures that may exist in the heating wall, sealing them off and preventing leaks. This graphite deposition becomes oxidized (by the oxygen of air) in the event of cross leakages from the heating chamber or outside atmosphere into the coking chamber, disrupting the hermetic-cal sealing of coking chambers. In addition, air entering the coking chamber may result in localized coke burning and ash formation.. [8]. in [9] the pressure inside the coking chamber and the suction at different locations of the heating system must be controlled in such a way that the likelihood of cross leakages from either side is kept to a minimal. However, occasionally a very small amount of foul gas leakage from the coking chamber to the heating chamber is allowed because it aids in the creation of graphite and the subsequent closing of cracks, etc. [10]. In [11] by modifying the reversal periods cycle, coke manufacturing industries can save a maximum of 300 to 400 (Nm3/hour) of coke oven gas. In [12] the primary uses of coke are the production of steel and the extraction of metals. Coke is a key ingredient in the production of high-grade steels in an integrated steel mill. The calibration of the flow meter is changed in the current study project. By changing the gas flow meter calibration, the coke oven's gas flow was reduced from 17100 Nm3/hour to 16900 Nm3/hour, saving 200 Nm3 per hour without adding any further labour costs. In [13] in this study, the appropriate upkeep of the gas channel can solve the smoke pushing problem. Energy use and economic expansion are entwined, and rising energy prices invariably translate into rising energy use. In blast furnaces, coke serves as a reducing agent and a load-handling device. This correction allowed the coke oven gas flow to be decreased from 17600 Nm3/hour to 17300 Nm3/hour without adding any additional labour costs. In [14] researcher describes that, Following the correction of coke oven gas leaks at various coke oven battery locations, the coke oven gas flow was lowered from 18500 Nm3/hr to 18400 Nm3/hr. As a result, the overall gas consumption for the coke oven is lowered by up to 100 Nm3/hr, and the particular heating consumption value is also decreased by up to 05 kcal/kg without harming the quality of coke producing. This strategy can save up to three lack's twenty four thousand rupees every month in Indian rupees. In [15] researcher comprises that, The size distribution and strength of metallurgical coke are crucial for the constant and high-efficiency operation of a blast furnace because these factors influence stack stacking ability. The impact and abrasion that occur during transfer to and descent in the blast furnace as well as its influence on the coke layer fracture that takes place during carbonization and its effects on the initial mean size and size distribution of the feed coke all have an impact on lump coke size. Therefore, it's crucial to comprehend the connection between coke strength and the fissure phonation phenomenon. Consequently, in this work, the coke strength growth during carbonization has been assessed together with a variety of factors.

Coke manufacturing plants have been working tirelessly to reduce undesired emissions from both the pusher side and the coke side of the oven doors. The coke oven collective had previously experimented with various door designs and door regulating techniques to lower coke oven gas emissions. PLD (percentage of leaky doors) is one way to measure the coke oven gas leakage from oven doors on the pusher side and the coke side. This paper describes, the different methodology can be adopted for reducing the coke oven gas consumption for coke making plant. By reducing the coke oven gas consumption, the specific heat consumption can also be reduced which provides the better prolongation and better health of the coke making plant. Specific heat consumption value of a coke making plant plays an important role for reducing the cost of coke making.[16, 17, 18, and 19]

2. objective- Firstly in this research, the flue maintenance activities like burner cleaning, orifice cleaning and distribution pipe cleaning is done on the only one time in a day like general shift wise. After the rectification of SOP, flue maintenance activities like burner cleaning, orifice cleaning and distribution pipe cleaning job is done in a day three times like A, B as well as C shift which is beneficial for the heating chamber flue temperature increment. After the temperature increment in all 32 flues the COG flow is also reduced in this research experiment. The COG flow is reduced from 12900 Nm3/hr to 12800 Nm3/hr, by the saving of COG flow in hourly basis of coke making plant coke making cost also can be reduced.

2. Methods

Experimental research details- in this research flue maintenance of all 32 flues are a prime job to improving the flue wise temperature. Firstly the flue maintenance activities like burner cleaning, orifice cleaning and distribution pipe cleaning is done on the only one time in a day like general shift wise. After the rectification of SOP, flue maintenance activities like burner cleaning, orifice cleaning and distribution pipe cleaning job is done in a day three times like A, B as well as C shift which is beneficial for the heating chamber flue temperature increment. In this research experiment there are 73 number of total production target is taken in a day. The total coke making time this is taken as 22.027 hours, on dry basis coal charge per oven is 31 tones and pause time is taken as 01 minutes. The different type's mathematical formula which is in this research is given below.

3.1 Coke making time (CMT) formula in coke making plant

It includes mathematical equation formula of coke making period

$$(\mathrm{CMT}) = \frac{(\mathrm{N}_1)\times(24)}{(\mathrm{N})}$$ -------- (equation 1)

Where N= number of production target in a day total number of oven

N1= total number of oven

3.2 number of production target (N) formula in a day total number of oven

It includes mathematical equation formula of determining the number of production target like pushing and charging in a day wise schedule.

$$(\mathrm{N}) = \frac{(\mathrm{N}_1)\times(24)}{(\mathrm{CPD})}$$ ---------(equation 2)

Where N= number of production target in a day total number of oven

N1= total number of oven

3.3 COG flow mathematical formula (V)

It determines mathematical equation formula for determine the COG flow:

$$\mathrm{V} = \left[\frac{\mathrm{Q}*1000*\mathrm{N}*\mathrm{W}}{\mathrm{C.V}\times\mathrm{T}}\right]$$ -------- (equation 3)

Where, C.V =calorific value

W= dry basis per oven coal changing

Q= specific heat consumption in kcal/kg

All the above mathematical formula equation 01 to equation 03 is used in this research experiment, and final output reading the shown in table number 01 and table number 02 which is given below.

Discussion

Results with discussion- after the rectification process, the temperature of all 32 flues are increased up to 20 °c to 30 °c. After the increment of flue temperature of chamber wall the health of the oven is also improved in this research experiment. Before the rectification process the COG flow is up to 12900 Nm3 on hourly basis. After the rectification process in this research work the COG flow is up to 12900 Nm3 on hourly basis which is less flow before the rectification work. So that COG flow is reduced up to 100 Nm3 on hourly basis. The saving of COG on hourly basis in coke making plant is also reducing the cost of coke making. By using this research methodology the specific heat consumption value is also reduced from (545 kcal/kg) to (540 kcal/kg). The tabulation for temperature for heating flue before and after rectification process is given as table number 03. Process parameters for before the rectification process is described in table number 01

Table 01. Before rectification process parameters of coke making plant

Number of days	Before rectification Coke forming time	Before rectification COG Flow	Before rectification pause time	Before rectification specific heat consumption value	Before rectification Number of production target achieved in a day
01	22.02	12900	01	545	73

	7 hours	Nm3/ hr	minut es	kcal/kg	
02	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
03	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
04	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
05	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
06	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
07	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
08	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
09	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73
110	22.02 7 hours	12900 Nm3/ hr	01 minut es	545 kcal/kg	73

Table number 01 describes the experimental research process parameters, which is used in this research experiment. After the putting the value in equation 01, 02 and 03 of the mathematical formula, the final mathematical reading is shown in table number 01, these all reading is taken before the rectification process. After putting the value in equation 01 formula, the coke making time is taken as 22.027 hours. The total number of production target is taken as 73. First of all we have taken the previous data reading of 10 days before the rectification process. After the putting value in equation number 03, the specific heat consumption value is taken as (545 kcal/kg). Before the rectification process the pause time is also taken as 01 minute. The main aim of this research work after the rectification process the gas flow of COG have to reduced, due to which specific heat consumption value also can be reduced. After the rectification work the experimental reading is shown in table number 02 and 03 which are given below.

Table02. Before and after rectification process all heating wall average flue temperature

Flue No.	Before rectification chamber flue temperature	After rectification chamber flue temperature	Increment of flue wise temperature
01	1130°c	1160°c	30°c
02	1140°c	1170°c	30°c
03	1160°c	1190°c	30°c
04	1170°c	1200°c	30°c
05	1150°c	1180°c	30°c
06	1170°c	1190°c	20°c
07	1200°c	1220°c	20°c
08	1220°c	1240°c	20°c
09	1230°c	1260°c	30°c
10	1220°c	1250°c	30°c
11	1220°c	1250°c	30°c
12	1210°c	1240°c	30°c
13	1220°c	1250°c	30°c
14	1210°c	1240°c	30°c
15	1220°c	1250°c	30°c
16	1210°c	1240°c	30°c
17	1210°c	1240°c	30°c
18	1210°c	1240°c	30°c
19	1230°c	1260°c	30°c
20	1240°c	1270°c	30°c
21	1230°c	1260°c	30°c
22	1240°c	1270°c	30°c

23	1240°c	1270°c	30°c
24	1230°c	1260°c	30°c
25	1220°c	1250°c	30°c
26	1220°c	1250°c	30°c
27	1210°c	1240°c	30°c
28	1200°c	1230°c	30°c
29	1190°c	1220°c	20°c
30	1180°c	1210°c	30°c
31	1170°c	1200°c	30°c
32	1160°c	1190°c	30°c

The average temperature of the all heating wall is described in Table number 02.table 02 comprises that the temperatures of each of the 16 flues on the pusher side and the 16 flues on the coke side are measured. Prior to correction, the maximum temperature of the heating wall was measured to be 1240°c. The heating wall's maximum temperature is taken as 1270°c. Prior to correction, the minimum temperature of the heating wall was measured to be 1150°c. After the correction job the minimum temperature is improved as 1190°c. The end vertical in this research work considered as flue number 01, 02, 31 and 32. This end vertical flue temperature is also improved in this research work. Before the rectification of work process the flue temperature of 01 and 02 is around 1130°c and 1140°c. After the rectification process the flue temperature of 01 and 02 is around 1160°c and 1170°c which shows that vertical flue 01 and 02 temperature is increased up to 30°c. Before the rectification of work process of the flue temperature of 31 and 32 is around 1170°c and 1160°c. After the rectification process the flue temperature of 31 and 32 is around 1200°c and 1190°c which shows that vertical flue 31 and 32 temperature is increased up to 30°c

Table03. After rectification process parameters of coke making plant

N o. of	After rectification	After rectification	after rectification	After rectification	After rectification
days	Coke forming time	COG Flow	pause time	specific heat consumption value	Number of production target achieved in a day
01	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
02	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
03	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
04	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
05	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
06	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
07	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
08	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
09	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73
10	22.027 hours	12800 Nm3/ hr	01 minutes	540 kcal/kg	73

Table number 03 describe that after the rectification process, the experimental reading is taken in day wise like 10 days. After the putting the experimental value in equation 01, 02 and 03 of the mathematical formula, the final mathematical reading is shown in table number 03, these all reading is taken after the rectification process. After putting the value in equation 01 formula, the coke making time is taken as 22.027 hours which is constant. The total number of production target is taken as 73 are taken in this experimental research work. First of all we have taken the experimental data reading of 10 days after the rectification process. After the putting value in equation number 03, the specific heat consumption value is taken as (540 kcal/kg). After the rectification process the pause time is also taken as 01 minute which is also constant with respect to before rectification process. The main aim of this research work after the rectification process the gas flow of COG have to reduced, due to which specific heat consumption value also can be reduced . The COG flow is reduced from 12900 Nm3/hr to 12800 Nm3/hr. by the saving of COG flow in hourly basis, the specific heat consumption value is also reduced from (545 kcal/kg to540 kcal/kg). The comparison graph which is shown in figure o1 and figure 02 is given below.

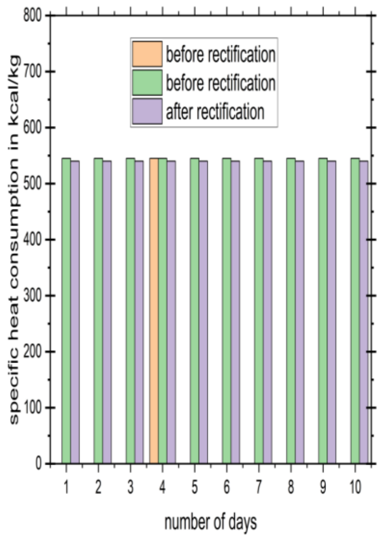

Figure01. Number of days with respect of specific heat consumption value

Figure 01 describes that graphical representation of number of days with respect to specific heat consumption value. The experimental data reading which is shown in table number 01 and table 03 which is used in figure number 01. It describe that the experimental reading before and after the rectification process for 10 days experimental research work. The total number of production target is taken as 73 are taken in this experimental research work. First of all we have taken the experimental data reading of 10 days after the rectification process. After the putting value in equation number 03, the specific heat consumption value is taken as (540 kcal/kg). By the saving of COG flow in hourly basis, the specific heat consumption value is also reduced from (545 kcal/kg to540 kcal/kg). So that reduction of specific heat consumption value also helpful for lowering the production cost of coke making.

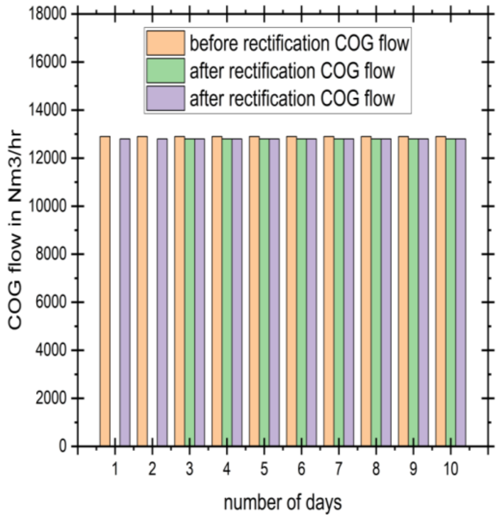

Figure02. Number of days with respect to COG flow of coke making plant

Figure 02 describes the number of days count with respect to COG flow before and after the rectification of work process. X axis shows the number of days count such as 10 days before and after the rectification work on the experimental basis. Y axis shows the COG flow comparing the before and the after the rectification process for 10 days experimental basis. The COG flow is reduced from 12900 Nm3/hr to 12800 Nm3/hr, by the saving of COG flow in hourly basis of coke making plant coke making cost also can be reduced.

The main aim of this research work after the rectification process the gas flow of COG have to reduced, due to which specific heat consumption value is also reduced . After the rectification process, the temperatures of all 32 flues are increased up to 20 °c to 30 °c. After the increment of flue temperature of chamber wall the health of the oven is also improved in this research experiment. The COG flow is reduced from 12900 Nm3/hr to 12800 Nm3/hr. by the saving of COG flow in hourly basis, the specific heat consumption value is also reduced from (545 kcal/kg to540 kcal/kg) of recovery type coke making industries.

Conclusion- In the coke manufacturing top charging battery, COG flow can be decreased by this research experiment from (12900 to 12800) Nm3/hr. The average Specific Heat Consumption value in kcal/kg of coke manufacturing facility can be decreased from (545to 540). After the SOP has been updated and corrected in this research experiment, the cost of producing coke can be decreased. Through this research study, up to 100 Nm3 of coke oven gas energy can be saved on an hourly basis. In the coke manufacturing plant, conserving coke oven gas energy aids in lowering carbon emissions. The hating flue temperature is improved by up to 20 to 30 degrees Celsius employing the research approach described above on a daily monitoring basis.

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Refrences

1. Bénard C, Berekdar S, Duhamel C, Rosset M-M. Input-Output Nonlinear Model of a Coke Oven Battery. IFAC Proc Vol 1989;22:95–9. https://doi.org/10.1016/b978-0-08-037869-5.50020-0.
2. Bénard C, Berekdar S, Rosset M-M, Depoux M. A Coke Oven Battery Modelization for Transient Operating Conditions. IFAC Proc Vol 1989;22:451–7. https://doi.org/10.1016/s1474-6670(17)53587-9.
3. Suzuki G, Mizuno M, Higuchi M, Matsushita T. Development of an Automatic Computer Control System for Coke Oven Operation. Trans Iron Steel Inst Jpn 1978;18:308–16. https://doi.org/10.2355/isijinternational1966.18.308.
4. Pang S, Lai Y. Hybrid intelligent control of coke oven. Int Rev Comput Softw 2011;6:1313–9. https://doi.org/10.5813/www.ieit-web.org/ijadc/2011.4.4.
5. Buczynski R, Weber R, Kim R, Schwöppe P. One-dimensional model of heat-recovery, non-recovery coke ovens: Part IV: Numerical simulations of the industrial plant. Fuel 2016;181:1151–61. https://doi.org/10.1016/j.fuel.2016.05.033.
6. Buczynski R, Weber R, Kim R, Schwöppe P. One-dimensional model of heat-recovery, non-recovery coke ovens. Part III: Upper-oven, down-comers and sole-flues. Fuel 2016;181:1132–50. https://doi.org/10.1016/j.fuel.2016.01.087.
7. Kostúr K. Control system of coking plant. Metalurgija 2002;41:121–4. https://doi.org/10.1016/s0140-6701(03)90704-1.
8. Razzaq R, Li C, Zhang S. Coke oven gas: Availability, properties, purification, and utilization in China. Fuel 2013;113:287–99. https://doi.org/10.1016/j.fuel.2013.05.070.
9. Kertcher LF, Linsky B. Economics of Coke Oven Charging Controls. J Air Pollut Control Assoc 1974;24:765–71. https://doi.org/10.1080/00022470.1974.10469967.
10. Smolka J, Slupik L, Fic A, Nowak AJ, Kosyrczyk L. CFD analysis of the thermal behaviour of heating walls in a coke oven battery. Int J Therm Sci 2016;104:186–93. https://doi.org/10.1016/j.ijthermalsci.2016.01.010.
11. Mahato N, Agarwal H, Jain J. Reduction of specific heat consumption by modification of reversal cycle period of coke oven battery.

Mater Today Proc 2021. https://doi.org/10.1016/j.matpr.2021.12.032
12. Mahato N, Agarwal H, Jain J. OPTIMIZATION OF SPECIFIC HEATING CONSUMPTION OF COKE OVEN PLANT USING FLOW METER CALIBRATION 2023;12:243–60.
13. Mahato N, Agarwal H, Jain J. Saving of Coke Oven Gas by Reduction of Smoke Pushing of Recovery Type Coke Plant. J Mines, Met Fuels 2023;70:449–55. https://doi.org/10.18311/jmmf/2022/32362.
14. Arabkoohsar A. Recent Advances in Mechanical Engineering. 2022. https://doi.org/10.1007/978-981-99-1894-2.
15. Cite P, Published THE, Record R. Strength of metallurgical coke in relation to fissure formation 2011.
16. Mahato N, Agarwal H & Jain, J, Experimental Decrement of Coke Oven Gas Flow by the Rectification of Heating Gas Leakage in Different Locations of Coke Plant Battery. In: Shukla, A.K., Sharma, B.P., Arabkoohsar, A., Kumar, P. (eds) Recent Advances in Mechanical Engineering. FLAME 2022, *Lecture Notes in Mechanical Engineering*, 2023
17. Mahato N, Agarwal H & Jain, J, Reduction of Coke Oven Gas Flow by Rectification of Undercharging of Oven of Coke Oven Battery. In: Sikarwar, B.S., Sharma, S.K., Jain, A., Singh, K.M. (eds) Advances in Fluid and Thermal Engineering. FLAME 2022, *Lecture Notes in Mechanical Engineering*, 2023.
18. Mahato N, Agarwal H & Jain, J, Experimental Reduction of Coke Oven Gas by Adjustment of Gas Flow in Pushing and Charging Schedule of Coke Oven Plant. In: Sharma, R., Kannojiya, R., Garg, N., Gautam, S.S. (eds) Advances in Engineering Design. FLAME 2022, *Lecture Notes in Mechanical Engineering*, 2023.
19. Mahato, N., Agarwal, H., Kumbhalkar, M. A., Sarje, S. H., Sakhlecha, M., Mohod, S. K., Kardekar, N. B., & Jain, J. (2025). Optimising Coke Oven Gas Consumption in Heat Recovery Coke Production. *AFRICAN JOURNAL OF APPLIED RESEARCH*, *11*(1), 212–227. https://doi.org/10.26437/ajar.v11i1.838