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OPTIMISING COKE OVEN GAS CONSUMPTION IN HEAT RECOVERY COKE PRODUCTION

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ABSTRACT
Purpose: This research aims to optimise natural gas consumption in heat recovery coke production by systematically investigating operational parameters and process modifications. The objectives are quantifying and reducing specific gas consumption while maintaining product quality standards and developing optimal operating parameters for manual charging operations.
Design/Methodology/Approach: The experimental design for optimising natural gas consumption in coke production focuses on systematically evaluating and improving energy efficiency while maintaining product quality. The experimental runs are randomised to minimise systematic bias, with each condition replicated three times to ensure statistical validity. Statistical analysis employs Analysis of Variance (ANOVA) to determine significant factors.
Findings: Reducing heating gas leakage significantly improved temperature regulation within the Coke plant. Rectification measures enhance temperature distribution and optimise fuel consumption in the heating process. Saving coke oven gas energy as heating gas energy is also helpful for reducing the specific heat consumption value of coke-making plants in an integrated type of steel industry.
Research Limitation: This research is focused on recovery type coke making plants in integrated type steel industries
Practical Implication: These findings demonstrate that optimising coke oven gas consumption improves the efficiency of coke-making operations and generates substantial benefits across the entire integrated steel manufacturing process.
Social Implication: The social implications demonstrate that energy optimisation in coke-making plants contributes significantly to sustainable community development and social progress.
Originality/Value: Saving coke oven gas energy as heating gas is also helpful for reducing the specific heat consumption value of coke-making plants in an integrated steel industry.
Keywords: *Coke production. heat. maintenance. natural gas. optimising.*

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INTRODUCTION

The making plant has been striving to minimise the unwanted emissions from the coke oven doors of the pusher and coke sides.The Coke oven collective had earlier tried different designs of doors and different methods of door regulation to reduce Coke oven gas emissions. The coke oven gas leakage from oven doors of the pusher side and coke sides is measured such as PLD (percentage of leaking doors) (Panchbhai & Jain, 2020). In coke ovens, coal is destructively distilled to create coke.

A specially prepared coal blend of different types of coal with the necessary coking properties is heated (coke) in an oxygen-free environment until most of the coal's volatile components are gone. The manufacturing of coke is a helpful case study because fugitive emissions have been subject to technology-based regulation in this sector. This report examines the method's effectiveness in reducing coke oven emissions and potential future applications.(Panchbhai & Jain, 2020a). The Indian government's environmental standards for a recovery-style coke oven facility are included in this study report.

The manufacturing of coke is a helpful case study because fugitive emissions have been subject to technology-based regulation in this sector. This study assesses the method's effectiveness in reducing coke oven emissions and suggests improvements that may have been made. (Bandopadhyay et al., 2002). Coking, coal preparation, and recovering and upgrading coal derivatives occur at coke oven plants, which are sophisticated technological facilities made up of many technological sites. The heat is transferred from the heated brick walls into the coal charge to begin the coal-to-coke conversion. The coal disintegrates between 375 and 475°C, forming plastic layers close to each wall. This study aims to optimise natural gas consumption in heat recovery coke production by systematically investigating operational parameters and process modifications. The objectives are quantifying and reducing specific gas consumption while maintaining product quality standards and developing optimal operating parameters for manual charging operations.

LITERATURE REVIEW

The evolution of tars and aromatic hydrocarbon compounds is noticeable between 475 and 600 °C, and the plastic mass then re-solidifies into semi-coke. The coke stabilisation phase starts at 600 to 1100 degrees Celsius. Coke mass contraction, coke structural development, and the final evolution of hydrogen are characteristics of this. The plastic layers advance from each oven wall towards the centre during this stage (Kwieciñska et al., 2017)**.** For every tonne of steel produced in a traditional blast furnace, 770 kg of coking coal is needed. For every tonne of steel produced by the blast furnace route, approximately 2 tonnes of CO_2 are released into the atmosphere.

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Additionally, this route generates by-product gases that offer intriguing perspectives for potential recycling. Blast furnace gas (BFG), essential oxygen furnace gas (BOFG), and coke oven gas (COG) are the three main off-gases produced. These sporadic gases, including CO, CO_2, and CH_4, are traditionally burned in flares or used for energy integration in steel mills without any financial gain. Carbon Capture and Utilisation (CCU) may provide some intriguing ways to reduce these emissions of greenhouse gases (Portha et al., 2021). The carbonisation process describes the conversion of coal into coke without air.

Flue gases, or combusted volatile materials, are gathered in a common tunnel. Waste heat recovery boilers recover heat from the flue gases, converting the excess heat into steam for power generation. As a result, the procedure is also known as "heat recovery coke making." Plant for Sorting Coke: Screen and crush coke to the metallurgical coke size of 25–80 mm that blast furnaces need. Breeze coke, which is in the 0-10 mm fraction, is used to make the sinter, and nut coke, which is in the 10-25 mm fraction, is added to the sinter that is given to the blast furnace (Rao et al., 2023).

In the recovery-making industry, different methodologies are used to reduce heating gas, like coke oven and mixed gas, without hampering coke quality. In this methodology, heating gas flow is reduced in a standard safety regulation of the coke-making plant without hampering the quality of the coke and the coking periods of the coke oven plant.

The methodology includes reducing the reversal cycle periods, calibration of heating gas flow meters and reducing the smoke or green type pushing in integrated steel plant (Mahato et al., 2022a, 2022b; Mahato & Jain, 2023). Mechanical stability and a consistent, high density over the cake volume are requirements for stamped and pressed coal cakes. In addition to coal selection factors, the efficiency of the process is primarily influenced by the operating variables compacting time and energy for coal cake production and by the adequate mechanical stability of the cake to ensure trouble-free oven charging.

The two sub-processes of densification and strengthening during stamping and pressing are studied theoretically and experimentally at the Department for Mechanical Process Engineering & Solids Processing of the Technical University Berlin using a specially developed lab-scale compacting test (Kuyumcu & Sander, 2014). The Coke oven is a crucial piece of thermal equipment that uses much energy in the metallurgical sector. Therefore, the main issues with coke oven control and management are conserving energy while enhancing production and coke quality.

An intricate intermittent thermal process is coking. Automation control is challenging because of the coke oven's intricate structure, highly demanding operating conditions, and scarcity of testing facilities. The objectives of cooking process control include achieving stable coke oven heating, boosting coke production and quality, lowering energy consumption and extending coke oven

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service life, and reducing environmental pollution during cooking production (Li et al., 2013). This study discusses the mathematical modelling of HR/NR coke ovens. It develops one-dimensional models for combustion and heat transport in downcomers, sole flues, and the area above the coking bed (upper oven).

The well-stirred reactor concept is used to simulate the area above a coking bed, whereas the long plug-flow furnace concept is used to model additional oven branches. The computer simulations show that the downcomers and sole-flue channels experience a slow, regulated burning of gaseous mixtures. This type of conduct is typical of commercial coke furnaces. The primary heat transfer method, thermal radiation, is responsible for up to 90% of all heat transfer rates. The mathematical model also calculates refractory temperatures, and in some sole-flue branches, they approach too high levels that may render (Buczynski et al., 2016). The new optimal control system design is gradually realised. This boosts the economy without increasing expenses or technological investments. For instance, achieving the stabilisation level alone results in a 3% energy savings.

A novel design for optimum control of coke batteries was proposed to lower the energy cost of producing coke. The first optimisation step uses variations in the coke battery's individual blocks' capacity to conduct heat. It is currently in the verification phase. The second optimisation level has already been attained. (Kostúr, 2002).The making plant consists of a heating wall maintained from 1200 to 1300 degrees centigrade as per the requirement of the production target of the making plant. To maintain the temperature from 1200 to 1300 degrees centigrade, a definite amount of suction draft is maintained for good quality coke productivity. The important working part of a coke-making plant is the regenerator. Regenerators play an important role in making coke plants.

A regenerator is a pathway of clean coke oven gas and waste heat gas of heating wall chambers. The regenerator is made of a special type of silica bricks, which is constructed by checker bricks. The making plant has been striving to minimise the unwanted emissions from the coke oven doors of the pusher and coke sides. The Coke oven collective had earlier tried different designs of doors and different methods of door regulation to reduce Coke oven gas emissions. The coke oven gas leakage from oven doors of the pusher side and coke sides is measured such as PLD (percentage of leaking doors) (Mahato et al., 2023a, 2023c). The percentage of leaking doors value will be maintained per the country's pollution board. The PLD value is to be maintained by using asbestos ropes for sealing.

India's Central Pollution Control (CPCB) has fixed a norm of below 10 per cent PLD for a running old coke oven battery and a maximum of 5 per cent PLD for a new coke oven battery. It is observed that the coke oven gas emission from the coke oven doors of the pusher and coke sides is still a headache. In this research paper, the sealing capabilities of coke oven doors and requirements for perfect coke oven gas emissions prevention may be reported as a successful result. The Coke-making complex is a complicated area where maximum coke oven gas pollution is generated in an

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integrated steel plant. Generally, conventional coke oven doors are used in coke-making plants, prone to heavy leakage of hazardous gases, flames, heat, and dust. Due to these reasons, the coke-making oven complex is considered a risky area to work in, where the workman is exposed to pollution, resulting in low productivity. This is the main reason for concerns about the maximum integrated type of steel plant (Mahato et al., 2023b; Dumanwad et al., 2023; Kumbhalkar et al., 2023).

Due to lacking one-man charging, the standard value of PLO (Percentage of leakage of off-take) as per India's Central Pollution Control (CPCB) is not maintained due to a huge penalty that must be charged to the company. The standard value of PLO (Percentage of leakage of off-take) as per the Central Pollution Control (CPCB) is four. Due to the lack of pressure or pressure drop of high-pressure liquor ammonia, coal is directly charged into the heating oven, called off-man-coal charging. Using this methodology, huge amounts of raw coke gas and coal dust are liberated into the open environment and exceed the standard value of PLO (Percentage of leakage of off-take). The mechanical maintenance work of the high-pressure liquor ammonia nozzle should be done daily, and the desired pressure and flow of the high-pressure liquor ammonia should be maintained in A, B, and C shifts, respectively. The maintenance job of the gas flue path area is also maintained, and the temperature of all heating chamber flues is taken in shifts, such as before and after the modification process.

METHODS

The experimental design for optimising natural gas consumption in coke production focuses on systematically evaluating and improving energy efficiency while maintaining product quality. The research utilises a factorial design approach incorporating multiple process variables and their interactions.

The experimental runs are randomised to minimise systematic bias, with each condition replicated three times to ensure statistical validity. Control measures include standardised feed material specifications (volatile matter 25±2%, moisture 8±1%), consistent operating crew assignments, and regular equipment calibration.

Experimental setups are conducted in a coke manufacturing factory with a 7-meter height. The coke manufacturing facility comprises 67 ovens, 68 heating chamber walls, and 69 waste heat boxes. For example, each oven's effective volume is 41.6 M3.50mm in total length taper. Pusher and coke sides are the two sections that make up the heating flues. Pusher sides have 16 flues, while Coke sides also have 16 flues. The heating flues are vertically paired with one inside the other. The pusher side is 385mm wide, while the coke side is 435mm wide. The heating oven's width is typically 410mm. On a dry basis, each oven produces roughly 25 tonnes of coke and charges about 32 tons of coal. Day-wise, the pushing production count is taken as 80. It contains.

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A recovery-type coke manufacturing plant is a coke oven battery. It comprises a regenerative design, an under-jet firing technology, and fireclay and silica refractory bricks.

Statistical analysis employs Analysis of Variance (ANOVA) to determine significant factors.

Coke oven gas calorific value

The desired average calorific value of coke oven gas is around 4200 kcal/Nm3. The calorific value comprises the amount of heat energy liberated for the unit Nm3 complete burning of coke oven gas. In this experimental process, the calorific value of coke oven gas is taken at 4200 kcal/$Nm^{3.}$

C.P.T value in recovery type-making plant

It includes the mathematical equation formula of the making period.

$$(\text{C.P.D}) = \frac{(\text{number of oven})\times(24)}{\text{pushing target}}$$

Where C.P.T= Coking period duration in hours
Number of oven = 67
Pushing target in a day=75
As we know, the equation formula

$$(\text{C.P.D}) = \frac{(\text{number of oven})\times(24)}{\text{pushing target}}$$

$$(\text{C.P.D}) = \frac{(67)\times(24)}{75} = 21.44 \text{ hours}$$

In this research work coking period duration is taken as 21.44 hours

Periods of COG flow in hr.(T)

T= 24-[(R×24)/60)]
Where T= Periods of COG flow in hours
R=number of reversals in one hour = 03
We know the equation formula, such as
T= 24-[(R×24)/60)] hours
T= 24-[(03×24)/60)]=(24-1.2)hours
T=22.8 Hours.

COG flow requirement mathematical equation formula

It includes a mathematical equation formula for determining the COG flow:

$$V = [\frac{Q*1000*N*W}{C.V\times T}] \text{ --------(equation 2)}$$

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Before modification, COG Flow in Nm3/hour

Q= Specific heat consumption value in kcal/kg
Before modification of the work, the experimental value of Q=610 Kcal/kg
N= Number of pushing=75
W= Dry basis coal charged /oven =31.5 tones
C.V= 4200 kcal/Nm^3
T= 21.44 hours
As we know, the equation formula of the requirement of COG flow

$$V = [\frac{Q * 1000 * N * W}{C.V \times T}]$$

$V = [\frac{610*1000*75*31.5}{4200\times22.8}]$=15000 Nm3/hour

After modification COG Flow in Nm^3/hour

Q= Specific heat consumption value in kcal/kg
Before modification of the work, the experimental value of Q=600 Kcal/kg
N= Number of pushing=75
W= Dry basis coal charged /oven =31.5 tones
C.V= 4200 kcal/Nm^3
T= 21.44 hours
As we know, the equation formula of the requirement of COG flow

$$V = [\frac{Q * 1000 * N * W}{C.V \times T}]$$

$V = [\frac{600*1000*75*31.5}{4200\times22.8}]$ =14800 Nm3/hour

RESULTS AND DISCUSSION

The temperature of all 32 flues of the pusher side and the coke side was taken. The temperature readings were taken in both cases, such as before and after controlling the oven door emissions of the job. There are 68 heating walls in the Coke oven plant and 67 oven chambers. Work was done on 03 heating walls, like 01,30 and 67, with several heating wall temperatures before and after the modification of work. The experimental temperature reading, which is taken, is shown in Tables 1 to 4. The experimental temperature

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Table 1: Pusher side & coke side of the temperature of heating chamber wall no- 01

Serial NO.	Numbering of flues on the pusher side	01 number heating wall flue temperature in pusher side area before rectification	01number heating wall flue temperature in pusher side area after rectification	Numbering of flues on the coke side	01 number heating wall flue temperature in coke side area before rectification	01number heating wall flue temperature in coke side area after rectification
01	01	1130	1140	17	1240	1260
02	02	1130	1140	18	1230	1260
03	03	1150	1160	19	1250	1270
04	04	1170	1180	20	1250	1280
05	05	1190	1210	21	1240	1270
06	06	1210	1220	22	1250	1270
07	07	1220	1230	23	1250	1280
08	08	1240	1250	24	1260	1280
09	09	1240	1250	25	1250	1280
10	10	1220	1240	26	1240	1270
11	11	1230	1240	27	1230	1260
12	12	1240	1250	28	1210	1230
13	13	1240	1250	29	1190	1220
14	14	1230	1250	30	1180	1190
15	15	1230	1240	31	1160	1180
16	16	1240	1250	32	1150	1170

In the study, Table 2 presents the temperatures recorded from 32 flues, divided equally between the pusher and coke sides of the coke plant, each containing 16 flues. The temperatures are shown in two columns: one for the pre-rectification temperature and the other for the post-rectification temperature of the heating walls. The pusher sides and coke sides are listed individually to allow for comparison. Before the rectification of the job, the maximum temperature observed on the pusher sides was 1240°C. After the rectification, the temperature increased to 1250°C. Similarly, the maximum temperature on the coke sides before rectification was recorded at 1260°C, which then increased to 1280°C after the rectification process.

These findings are in line with the work of (Mahato et al., 2023a), which emphasised that rectification measures, such as reducing heating gas leakage, significantly improved temperature regulation within the coke plant. Their study demonstrated that rectifying heating gas leaks in various locations of the coke plant battery improved the efficiency of the heating process, similar

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to the temperature increases observed in both the pusher and coke sides after rectification in this study. This aligns with their conclusion that rectification contributes to better thermal control, optimising the performance of the coke plant. The details of temperature fluctuation in the pusher and coke sides are described in Figure 1.

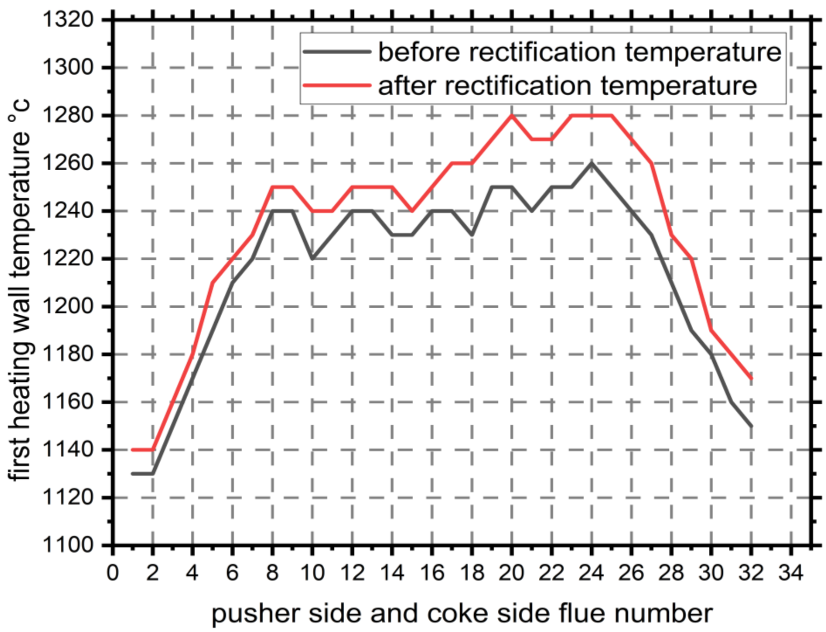

Figure 1: Temperature fluctuation in the pusher and coke sides

Figure 1 presents the temperature variance of the 1st heating wall, explicitly comparing the pusher and coke sides of the flues. Before rectification, the temperature observed for flue number 01 on the pusher side was 1130°C. After rectification, the temperature increased by 10°C, reaching 1140°C. Similarly, flue number 02 saw a temperature increase of 10°C after rectification, rising from 1130°C to 1140°C. On flues 15 and 16, the temperatures were recorded as 1230°C and 1240°C before rectification. Post-rectification, the temperature in flue number 15 remained at 1240°C, while flue number 16 increased to 1250°C.

For the coke side, flue numbers 17 and 18 initially had temperatures of 1240°C and 1230°C, respectively, before rectification. After the rectification, both flues 17 and 18 saw a temperature increase, reaching 1260°C. The end vertical coke side flue temperatures, 31 and 32, were recorded as 1160°C and 1150°C before rectification. Post-rectification, these temperatures increased to 1180°C and 1170°C, respectively.

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These observations align with the findings of (Mahato & Jain, 2023), who investigated the optimisation of specific heating consumption in coke oven plants. They emphasised that rectifying gas leakage and improved heating efficiency increased the plant's temperature uniformity, particularly in critical areas like the pusher and coke sides. Their research confirmed that such rectification measures enhance temperature distribution and optimise fuel consumption in the heating process, directly correlating with the temperature improvements observed in this study.

Table 2. Pusher side & coke side of the temperature of heating chamber wall no- 50th

Serial NO.	Numbering of flues in the pusher side	50th number heating wall flue temperature in pusher side area before rectification	50thnumber heating wall flue temperature in pusher side area after rectification	Numbering of flues in the coke side	50th number heating wall flue temperature in coke side area before rectification	50thnumber heating wall flue temperature in the coke side area after rectification
01	01	1130	1140	17	1240	1250
02	02	1140	1150	18	1240	1260
03	03	1150	1160	19	1260	1270
04	04	1160	1170	20	1250	1280
05	05	1180	1210	21	1240	1270
06	06	1210	1220	22	1250	1270
07	07	1220	1230	23	1250	1280
08	08	1240	1250	24	1260	1280
09	09	1240	1250	25	1250	1280
10	10	1220	1240	26	1240	1270
11	11	1230	1250	27	1230	1260
12	12	1220	1240	28	1210	1230
13	13	1240	1250	29	1200	1210
14	14	1230	1250	30	1180	1190
15	15	1230	1240	31	1170	1180
16	16	1240	1250	32	1160	1170

Table 2 presents temperature measurements from the 32 flues, with 16 flues on each side—pusher and coke. Table 4 illustrates the temperature of heating wall number 50th, showing the temperatures before and after the job's rectification in separate columns. The heating wall temperature includes the pusher and coke sides, each shown in columns for clarity.

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Before rectification, the maximum temperature observed on the pusher side was 1240°C. After the job was rectified, the maximum temperature increased to 1250°C. On the coke side, the temperature before rectification was 1260°C, while after rectification, the maximum temperature rose to 1280°C.

These findings align with the work of (Mahato et al., 2023a), who investigated the effect of rectifying heating gas leakage at various locations within the coke plant battery. Their study demonstrated that rectifying gas leakage significantly improved thermal efficiency and temperature distribution across the plant. Similar to the results presented in this study, they observed temperature increases after rectification, highlighting the positive impact of such measures on optimising the heating process in coke-making plants. This study supports the notion that effective rectification of heating gas flow can enhance temperature control, as evidenced by the increased temperatures in both the pusher and coke sides following rectification.The details of temperature fluctuation in the pusher and coke sides are described in Figure 2.

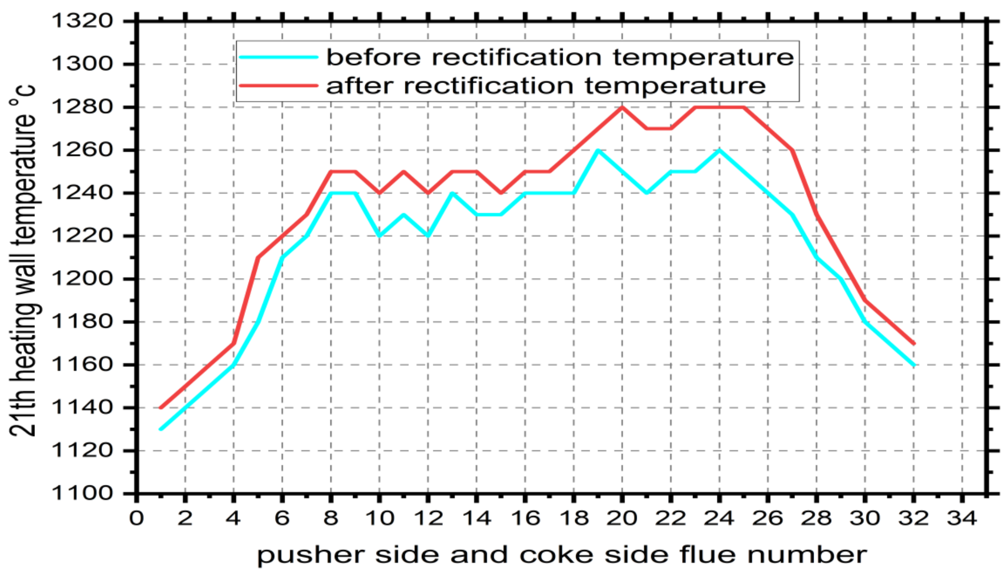

Figure 2: 50th heating chamber wall temperature with heating flue number

Figure 2 describes the temperature variance of the 50th heating wall concerning pusher sides and coke sides of flues.1130°c temperature of flue number 01 is observed before the rectification in pusher sides. After the rectification of job flue number 01, the temperature is increased up to 10°c and recorded as 1140°c. Flue number 02 temperatures also increased by 10°c after the rectification of the job, and temperature increased from 1140°c to 1150°c. Flue number 15 and 16 temperatures are recorded as 1230°c, 1240°c before rectification. After rectifying the job, flue number 15 is

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recorded as 1240°c, and flue number 16 is recorded as 1250°c. Coke side's flue numbers 17 and 18 are 1240 °C and 1240 °C before rectification. After rectifying job flue number 17, 18 temperatures are observed, such as 1250°c and 1260°c. The end vertical of the Coke side's flue numbers 31 and 32 temperatures are such as 1170°c and 1160°c. After rectifying job flue numbers 31 and 32, temperatures are increased and recorded as 1180°c and 1170°c, respectively.

Table 3. Pusher side & coke side of the temperature of heating chamber wall no- 67th

Serial NO.	Numbering of flues in the pusher side	67th number heating wall flue temperature in pusher side area before rectification	67th number heating wall flue temperature in the pusher side area After rectification	Numbering of flues in the Coke side	67th number heating wall flue temperature in coke side area before rectification	50th number heating wall flue temperature in the coke side area After rectification
01	01	1130	1140	17	1240	1250
02	02	1140	1150	18	1240	1260
03	03	1150	1160	19	1260	1270
04	04	1160	1170	20	1250	1280
05	05	1180	1210	21	1240	1270
06	06	1210	1220	22	1250	1270
07	07	1220	1230	23	1250	1280
08	08	1240	1250	24	1260	1280
09	09	1240	1250	25	1250	1280
10	10	1220	1240	26	1240	1270
11	11	1230	1250	27	1230	1260
12	12	1230	1250	28	1210	1230
13	13	1240	1250	29	1200	1220
14	14	1230	1250	30	1180	1190
15	15	1230	1240	31	1170	1180
16	16	1240	1250	32	1160	1170

Table 3 describes the pusher sides and coke sides of the temperature separately. The pusher sides contain 16 flues, and the Coke sides also contain 16. It includes the 32 flues of temperature. The 67th heating wall temperature includes the pusher sides and the coke sides' temperature in a separate column. The maximum temperature on pusher sides, such as 1240°c, is observed before rectification. After rectifying the job, the maximum temperature is 1250°c on the pusher sides of the coke plant. The maximum temperature in the coke sides is observed, such as 1260 °C, before

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the job is rectified. In coke sides, the maximum temperature is recorded as 1280°c after rectifying the job. The details of temperature fluctuation in the pusher and coke sides are described in Figure 3.

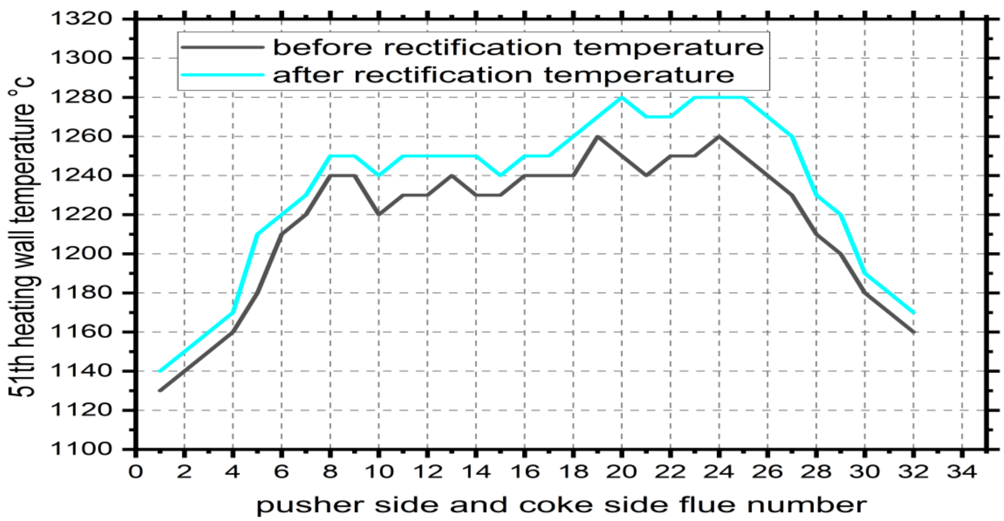

Figure 3: 67th heating chamber wall temperature with heating flue number

Figure 03 describes the temperature variance of the 67th heating wall concerning the pusher and coke sides of the flues.1130°c temperature of flue number 01 is observed before the rectification in pusher sides. After the rectification of job flue number 01, the temperature is increased up to 10°c and recorded as 1140°c. Flue number 02 temperatures also increased by 10°c after the rectification of the job, and temperature increased from 1140°c to 1150°c. Flue number 15 and 16 temperatures are recorded as 1230°c, 1240°c before rectification. After rectifying the job, flue number 15 is recorded as 1240°c, and flue number 16 is recorded as 1250°c. Coke side's flue numbers 17 and 18 are 1240 °C and 1240 °C before rectification. After rectifying job flue number 17, 18 temperatures are observed, such as 1250°c and 1260°c. The end vertical of the Coke side's flue numbers 31 and 32 temperatures are such as 1170°c and 1160°c. After rectifying job flue numbers 31 and 32, temperatures are increased and recorded as 1180°c and 1170°c, respectively. This graph shows that after the job was rectified, the temperature increased without affecting the desired Coke quality.

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Table 4: Tabulation for experimental data of first week to eighth week

Serial number	Weekly average data	Before modification COG Flow in Nm^3/hour	After modification COG Flow in Nm^3/hour	Before modification Q Value in kcal/kg	After modification Q Value
01	First week	15000	14800	610	600
02	Second week	15000	14800	610	600
03	Third week	15000	14800	610	600
04	Fourth week	15000	14800	610	600
05	Fifth week	15000	14800	610	600
06	Sixth week	15000	14800	610	600
07	Seventh week	15000	14800	610	600
08	Eight week	15000	14800	610	600

Table 4 describes the experimental research data outcomes before and after the modification work. Before modifying the research work, the coke oven gas flow requirement was around 15000 Nm^3/hour, which is too high. After the modification of the research work, the coke oven gas flow requirement was 14800 Nm^3/hour without affecting the quality of the coke. By using this methodology. The saving of coke oven gas up to 200 Nm^3 hourly, due to which specific heat consumption value is also reduced (610 to 600) in kcal/kg.

CONCLUSION

The saving of coke oven gas is up to 200 Nm^3 hourly, so the specific heat consumption value is also reduced (610 to 600) in kcal/kg without affecting the coke quality. The saving of coke oven gas energy as a heating gas energy is also helpful for reducing the specific heat consumption value of coke-making plants in an integrated steel industry. Using high-pressure liquid ammonia during the blended coal charging in a heating oven as an on-man type charging, the heating gas energy can be saved up to 360000 Nm^3 monthly.

These findings demonstrate that optimising coke oven gas consumption improves the efficiency of coke-making operations and generates substantial benefits across the entire integrated steel manufacturing process. It decreases overall energy costs in integrated steel plants, reducing the plant's carbon footprint through improved energy efficiency.

Reduced emissions from coke-making operations would improve air quality in surrounding communities and potentially reduce respiratory health issues in neighbouring areas. The social implications demonstrate that energy optimisation in coke-making plants contributes significantly to sustainable community development and social progress.

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The following recommendations should be adhered to: mechanical maintenance of the high-pressure liquor ammonia nozzle should be done daily, and the desired pressure and flow should be maintained in A, B, and C shifts, respectively. The gas flue path area is also maintained, and the temperature of all heating chamber flues is taken in shifts, such as before and after the modification process.

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