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Enhancement of steam generation in CDQ Power plant

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Abstract - *In CDQ system, the red hot coke is cooled by gas circulating in an enclosed system, The thermal energy of the red hot coke which is lost in the conventional system is collected and reused as steam (power generation) in the CDQ system. This technology uses less fossil fuel and result in lower CO2 emissions, thereby contributing to the prevention of environment pollution. Steam Generation is directly depend on hot charged in to CDQ chamber and cold coke discharged from the CDQ but in this case steam generation is less in A shift due to shutdowns in conveyor side(Cold coke discharge) and battery side(Hot coke charging) to overcome this for generation of stem provided bypass discharge system for continuous discharge of cold coke, but steam generation is less due to unavailability of hot coke then Next Stage of development for continuous generation of steam in CDQ boiler is injection of blast furnace gas at boiler inlet, When conducting BFG suction to ensure that it is a safety operation such as N2 replacing of air existing in piping, increasing BFG volume on the condition that circulation gas fan is open, air blower is open, boiler inlet gas temperature is above 700°C & less than 970°C and supplied BFG amount exceed 4,000Nm3/h, When BFG injection is not carried out, the steam basic unit is 580Kg/t-coke. This equipment increases the amount up to 750Kg/t-coke, Coke oven can increase the amount of steam generation of 59.3 t/h to 70.2 t/h by the injection of 13000Nm3/h BFG at a coke discharge rate of 94 t/h and power generation rate increased from 65MW to 70 MW*

Key Words: ***Coke Oven, CDQ, BFG Injection, Steam Generation***

1. INTRODUCTION

CDQ Plant recovers the coke oven sensible heat of hot coke by use of circulating gas, feed the recovered heat to boiler and generate steam for each plant. Locomotive is having two carriages and two buckets .Hot coke discharged from coke oven is put into one of bucket mounted on carriage and it is moved to under the lifting place of CDQ. Finally, the hot coke bucket is lifted by charging crane up to the top of crane support structure the top cover of charging facility is opened automatically by motor cylinder Next, the bucket is lowered and placed on the support installed at both sides of charging hole when the charging crane descended, the gate under the bucket is opened, and charging of hot coke is started once it is completed top cover is closed automatically. While hot coke is charging, charging facility and bucket are connected to dedusting duct so as to collect the coke dust generated. The charged hot coke (Max.1050°C) is cooled down to 200°C or below with the circulating gas in chamber and discharged to coke conveyor by discharging device The circulating gas is divided into for the central and the peripheral, and is blown to cooling chamber where the circulating gas is heated to Approx.800°C and fed to primary dust catcher (1DC) through sloping flue installed at the boundary between cooling chamber and pre-chamber. In the 1DC, bigger size of coke dust is separated. After passing through the 1DC, the circulating gas goes into boiler, where the sensible heat is recovered, and high-temperature and high-pressure steam is produced. The high-temperature and high-pressure steam is utilized as steam for general purpose. Before the gas goes into circulation fan, fine coke dust included in the circulating gas is removed so as to protect the circulation fan from abrasion. The circulating gas pressure at Approx.160°C after secondary dust catcher (Multicyclone/2DC) is increased by circulation fan. Many researchers are worked on CDQ. Hofei Liu et.al [1] Computational and Experimental Study of Cooling Process in Coke Dry Quenching Experimental Shaft A mathematical model based on the non-Darician and non-thermal equilibrium model for the cooling process of the CDQ experimental shaft was presented. Jasjeet Singh Kohli et.al [2] Boost To Blast Furnace Performance: A Perspective of coke cooling practice The review includes the assessment of effect of coke properties (coke moisture and CSR) on blast furnace characteristics to get better hold of the reasons for which change takes place due to use of coke dry quenching. Aravinda.P.A et.al [3] Computational Fluid Dynamics Analysis of Double flue Technology in Coke Dry Quenching. Lan-yi sun et.al.[4] Process Simulation Of An Integrated Coke Dry Quenching Combined Gasification Based on the minimization of the Gibbs free energy, the flow rate and composition of the syngas are predicted. The effects of the coke oven gas flow rate and the steam consumption on the flow rate and composition of the syngas as well as exergy efficiency is analyzed by using

PRO/II simulator. Marcelo RissoErrera et.al [5] A thermodynamic analysis (first and second laws) was performed for a coke dry quenching (CDQ) unit. Kai Sun et. al [6] Model predictive control for improving waste heat recovery in coke dry quenching processes they proposed a neural-network-based MPC approach and implemented it in the plant site the steam generation increased by 7%. The performance of the proposed MPC approach in the studied case was impeccable

2. PRESENT WORK

JSW Steel Ltd has 4 No's of CDQ facility at its Vijayanagar Works Plant. CDQ facility at JSW is more advanced, mature and reliable technology to make dry quenched metallurgical coke

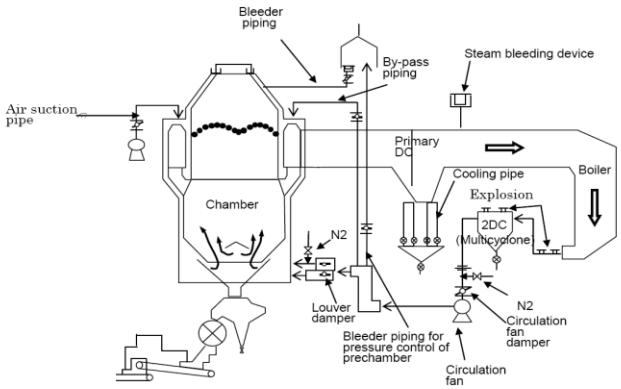
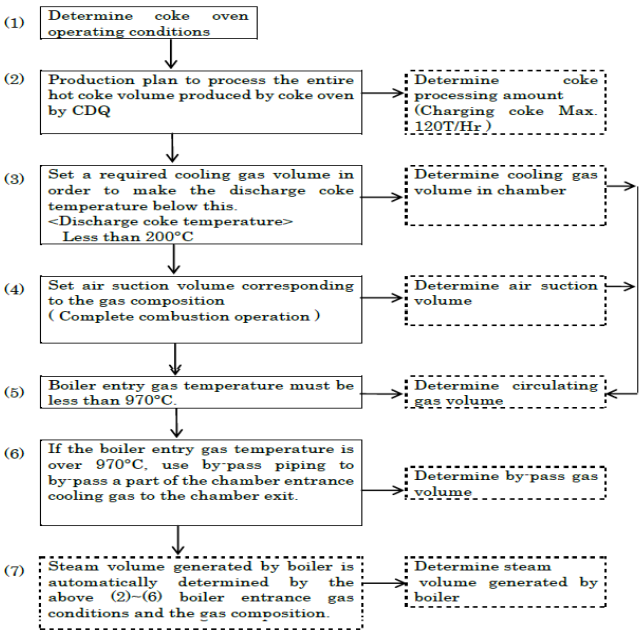


Fig 2.1: Flow diagram of CDQ

CDQ Operation plan



Abbreviations

CDQ-Coke Dry quenching
1DC-First dust catcher
2DC-Second dust catcher
TPH-Tons per hour
S/F- Sloping flue
BFG-Blast furnace gas

CDQ Specification

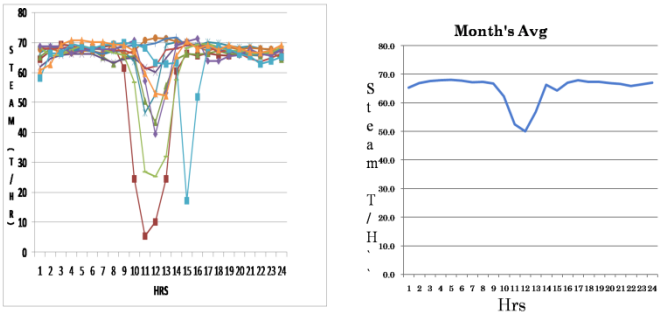
Maximum coke throughput	120 tph
CDQ facility in Coke Oven # 3	120 tph x 2 nos
CDQ facility in Coke Oven # 4	120 tph x 2 nos
Red hot coke temperature	1000±50 deg C
Cooled coke temperature	< 200 deg C
Boiler steam production capacity	Max 72 tph
Steam pressure	9.5 Mpa
Steam temp	540±5 deg C
Circulation gas volume	Max 1,80,000 m3/ hr
Circulation gas temperature at boiler inlet	970 deg C
Circulation gas temperature at cooling chamber inlet	130deg C

The operation conditions for coke oven 3(Total 224 ovens)
Coke through put is 85 T/H
Cold coke temp is less than 200 Deg C
Stem Generation is 0.58t- Steam/t -coke
Cycle time of Coke transportation system is less than 10.5 min
The operation conditions for coke oven 4(Total 288 ovens)
Coke through put is 112 T/H
Cold coke temp is less than 200 Deg C
Stem Generation is 0.58t- Steam/t -coke
Cycle time of Coke transportation system is less than 8.2 min
The rated capacity of CDQ Boiler is 72 TPH

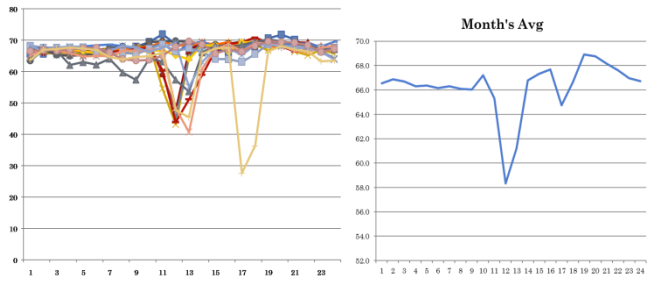
To get maximum stem generation in CDQ Power plant the hot coke charge and cold coke discharge through conveyor should be continuous

Analysis was conducted based on previous breakdown and delays the below following graphs shows steam generation trend over a period of 24 Hours

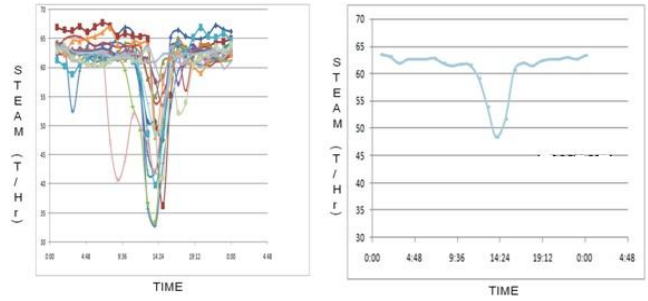
Steam Generation Trend in CDQ 1



Steam Generation Trend in CDQ 2



Steam Generation Trend in CDQ 3



Steam Generation Trend in CDQ 4

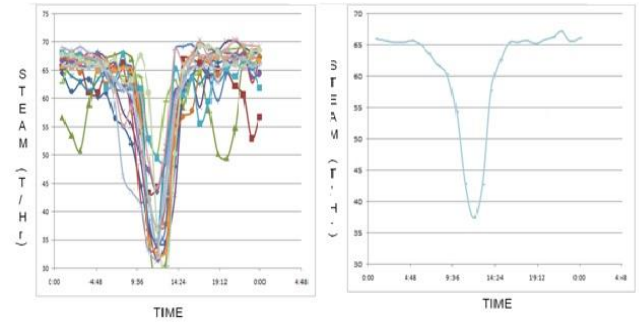


Fig 2.2: steam generation trend in different CDQ

From all the graphs it shows that steam generation is less between 9:00AM to 2:00 PM

Due to shutdowns in conveyor side and shutdowns in battery side on that time discharge is very less and hot coke input chamber also less hence steam generation is less at that time

2.1Conveyor Stoppage Analysis

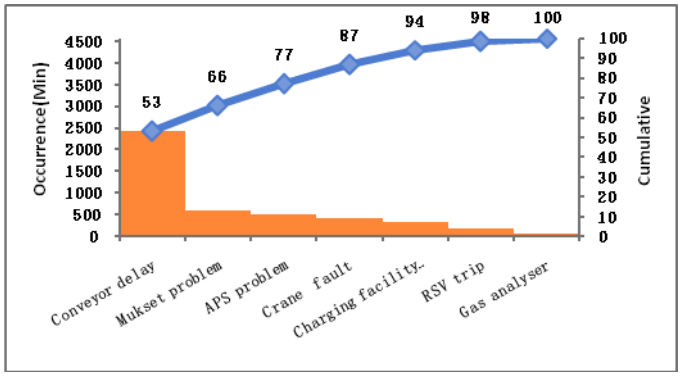


Fig 2.3: Pareto Analysis of CDQ 3 Delays

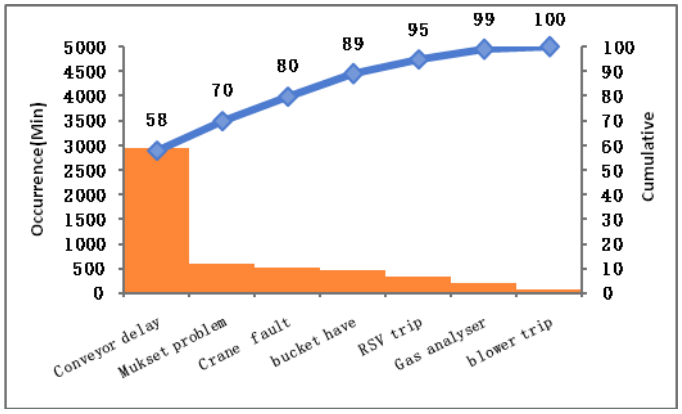


Fig 2.4: Pareto Analysis of CDQ 4 Delays

From pareto analysis it shows that the conveyor stoppage is the major contributing cause for steam generation and other CDQ problems

From all analysis it shows that following are the cases which affects the steam generation

1. In CDQ 1 & 2
   - During Conveyor shutdowns/Maintenance (A-Shift),steam generation is lower because of inadequate coke discharge
   - During Shut down/ cycle time in battery AB & CD

2. In CDQ 3 & 4
   - During Shut down/ cycle time in battery AB & CD.
   - During bucket cooling for liner plate changing

- Monthly one major shutdown in battery (6 Hours).
- During Conveyor shutdowns/Maintenance (A-Shift), steam generation is lower because of inadequate coke discharge.

2.2: Introduction of BFG at Boiler inlet for more steam generation

Next Stage of development for continuous generation of steam in CDQ boiler is injection of blast furnace gas at inlet of CDQ boiler.BFG piping is equipment installed to increase the amount of boiler steam. When BFG injection is not carried out, the steam basic unit is 580Kg/t-coke.

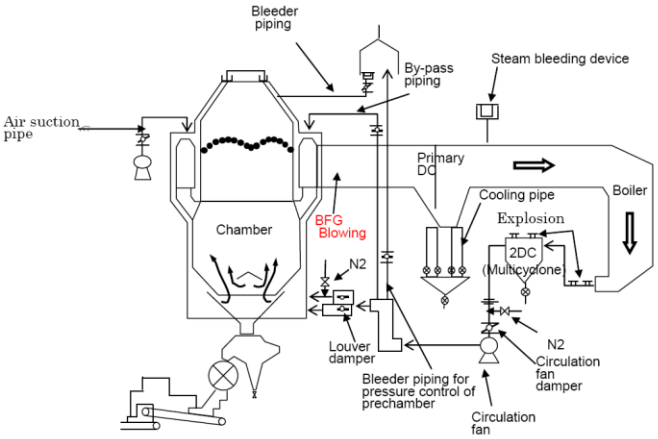
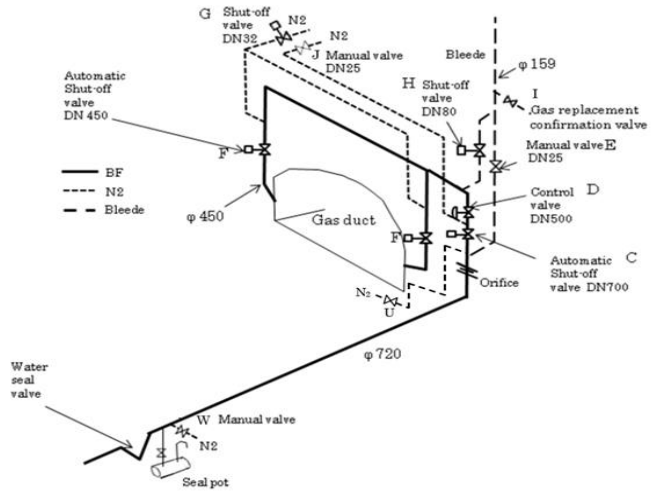


Fig 2.5: Introduction of BFG at Boiler inlet

Piping configuration for BFG



3. RESULTS AND DISCUSSION

After completing all pipe line configuration for BFG injection the following results are conducted

Coke Throughput calculation

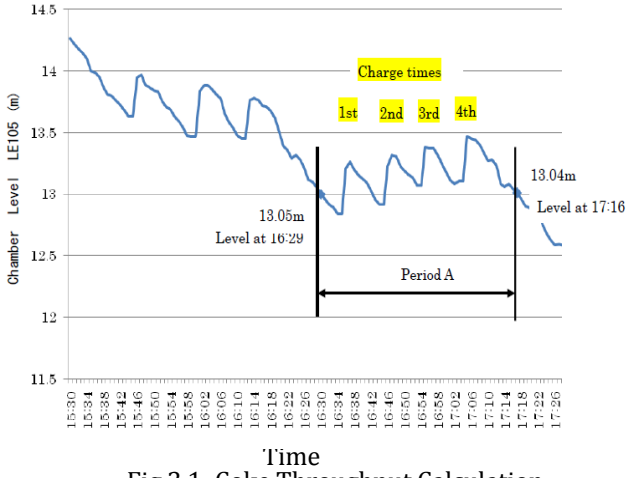


Fig 3.1: Coke Throughput Calculation

Period A from 16:29 to 17:16 (47min, 4charges)

The throughput per hour

60/47*4ch=5.11charges/hr ----a

Coke weight/1charge =18.2-18.4t----b

Coke throughput (a*b) = 92.9-94.0 t/h

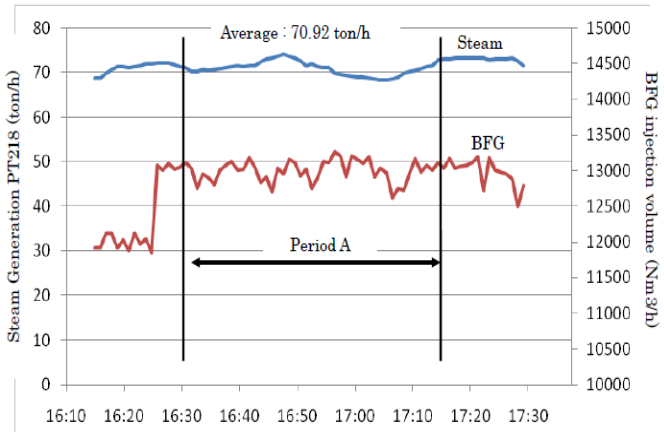


Fig 3.2: Steam Generation and BFG Volume V/S Time

Period A from 16:30 to 17:15 (45min)

Steam generation: Average. 70.92 t/h

BFG injection volume: Approx. 13,000 Nm3/h

Coke throughput: 92.9 to 94.0 t/h

Specific Steam Generation: 0.754 to 0.763 t-steam / t-coke

4. CONCLUSIONS

Coke Dry Quenching (CDQ) unit is a regenerative system to cool off the red hot coke with the recirculating inert gas in a chamber (shaft furnace) and to transfer thermal energy from the heated gas to water vapor through the heat recovery boiler. Owing to its functions of energy savings, environ mental protection and quality improvement of the coke, CDQ technology is favorite in coke making industry today. Steam Generation is directly depending on hot charged in to CDQ chamber and cold coke discharged from the CDQ. The operation of CDQ should be done by complete combustion operation; Circulation gas composition for complete combustion operation is H2 : 0.1% (Vol.%), CO : 0~0.3% (Vol.%), O2 : almost 0% (Vol.%) Cooled coke temperature should be operated below 200 deg C. There are two methods to adjust cooled coke temperature as describe below

a. Keep the coke process volume constant, and adjust with cooling gas volume

b. Keep the cooling gas volume constant, and adjust with coke process volume

When circulation gas volume is changed, the changed volume shall be within 3,000 Nm3/H with one action excessive change in circulating gas volume brings about a large temperature fluctuation at S/F and gives damage to brick, as well as increasing the amount of flying dust to cause the wear of boiler.

When conducting BFG suction change actions, to ensure that it is a safety operation such as N2 replacing of air existing in piping, increasing BFG volume on the condition that circulation gas fan is open, air blower is open, boiler inlet gas temperature is above 700°C & less than 970°C and supplied BFG amount exceed 4,000Nm3/h. At the moment, monitor the variable status for air suction volume as per ratio of BFG and Air volume. BFG piping is equipment installed to increase the amount of boiler steam. When BFG injection is not carried out, the steam basic unit is 580Kg/t-coke. This equipment increases the amount up to 750Kg/t-coke.

Coke oven can increase the amount of steam generation of 59.3t/h to 70.2 t/h by the injection of 13000 Nm3/h BFG at a coke discharge rate of 94 t/h and power generation rate increased from 65MW to 70 MW

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