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Increasing the Efficiency of De Dusting Car at Recovery Coke Ovens

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***Abstract*- De-dusting car frequently getting under capital repair at recovery coke ovens and also leakages are causing temperature variation of control vertical temperature in battery. The de dusting car is used for reduction of emission while charging, after some duration performance gets degraded and thus stack emission raise. Mainly emissions and capital repair arises due to the distortion of de-dusting car water jackets and refractory casting. "DOWNTIME" is happening every 6 months ,this is because of water cooling duct and ceramic casting distortion also leads to huge "EMISSION" from stack .hence there is rise of frequent maintenance in de-dusting car. De-dust car is the movable dust-collecting & dust-removing device While coal charging. Working principle of the equipment: while coal charging, guide sleeve of de-dust car aims at flue guide hole on the top of chamber to collect flue & dust, by turns enter into combustion chamber, connecting pipe, spray room, Venturi tube, cyclone separator, blower, then exhaust into the air. It improves equip level of coke oven and decrease flue & dust exhaust. De-dust car transfers the smoke from chamber while coal charging form the top of oven directly then exhaust after removing dust through burning. De-dust car is located on the top of oven. Supply voltage: 415V AC**

The function of the de-dusting car:-

1. **Emissions reduction while coal charging.**
2. **Converting charging emission gas into sludge water formation.**
3. **Maintaining the hot condition in combustion chamber before coal charging**.

***Keywords*--**

- **De-dusting car at recovery coke ovens**
- **Emissions**
- **Cost reduction after the modification.**
- **Capital repair**
- **Downtime**

I. INTRODUCTION

Definition Of Problem

1. De dusting car frequently getting under capital repair and also leakages causing temperature variation of control vertical temperature in battery.
2. The de dusting car is used for reduction of emission while charging, after some duration performance gets degraded and thus stack emission raise.
3. Mainly emissions and capital repair arises due to the distortion of de-dusting car water jackets and refractory casting.

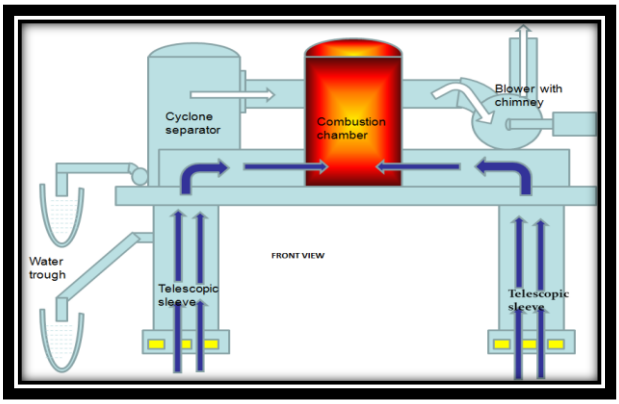

Fig 1

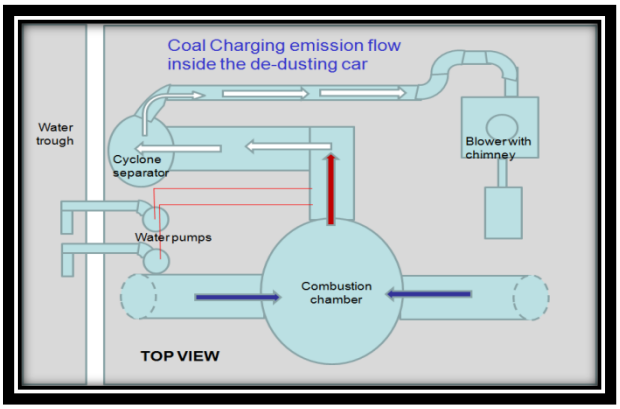

Fig2

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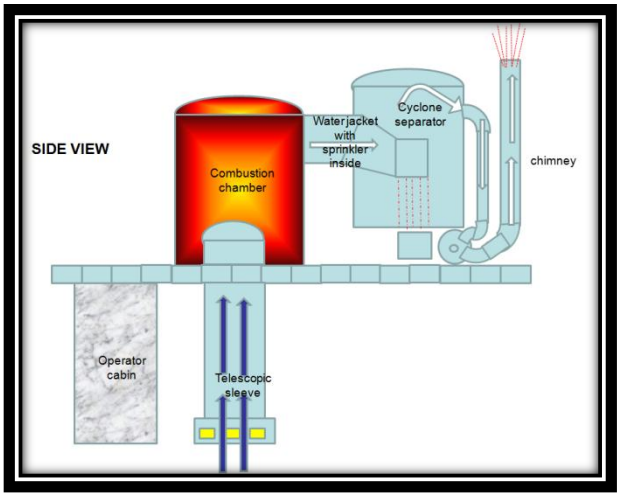


Fig 3

1. What is the problem?

The de-dusting car is used as de-dusting the emissions arises while the charging , but periodic distortion of water cooling jacket and refractory casting ,the leakages causing variation in battery temperature. Water cooling jackets and ceramic casting getting damaged every 6 month after, emissions where observed heavily during this stage.

2. Where does it happen?

In de-dusting car there is cooling water jacket where Continuously water supply is passed for avoiding convection of duct line but due to continues utilization it get distorted and also the ceramic casting, which is inside the main duct line.

3. When does it happen?

The circulation of water in cooling jacket was improper so the duct was getting distorted. The duct material used is MS iron which was easily getting damage.

4. Who is responsible?

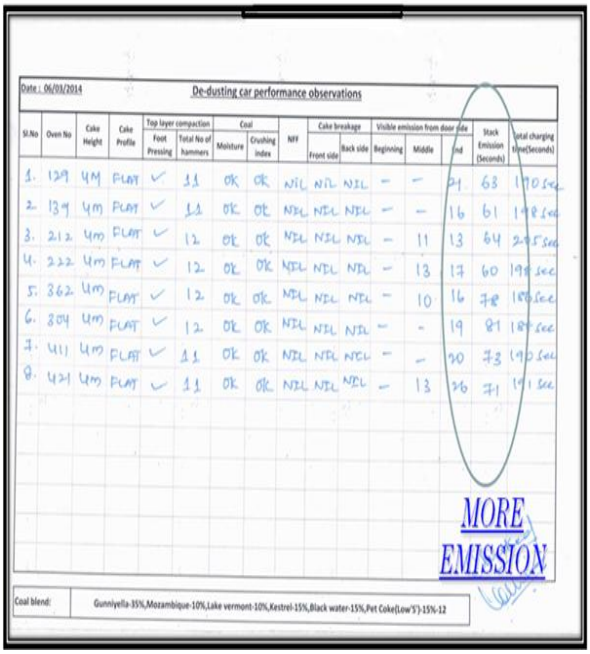
The problem may be lack of design application characteristics and material used in de-dusting car. In continues usage during high production may lead distortion of materials.

5. How does it happen?

The problem generated because of less area of water cooling jacket and making difficulty in circulation of hot water out, this hot water "retaining time" is increased inside the cooling jacket , which can damage the cooling duct when hot gas come in contact with the system. Also the ceramic casting is deformed frequently.

II. De-Dusting Car Performance

Table 1



The checklist shows that more emissions found during the coal cake charging.

III. Identification Of Causes

We conduct a brain storming session to identify the causes for coke spillage, and listed out various causes depending to the problem.

And the **causes** are as follows.

1. Frequently damage of water cooling jacket.
2. Pump stop condition during ideal position.
3. Material used for renovation of water jackets.
4. Damaging of spray nozzle inside the duct line.
5. Refractory casting damages.
6. Slow down of Combustion chamber temperature.
7. Variation of ph value of water inlet.
8. Leakages found in venturi duct.
9. Cyclone separator leakages.
10. Blower abnormal vibration.
11. Negligence of operator.
12. Not following the SOP.

After identification of causes, these causes were classified into four categories man, machine, material & method. Further we put the above causes into a fish bone diagram to find the root cause for coke fall as shown in fig1.

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Man, material & method related problem was identified but that doesn't play major role for inefficiency of de-dusting car as data described in below pages.

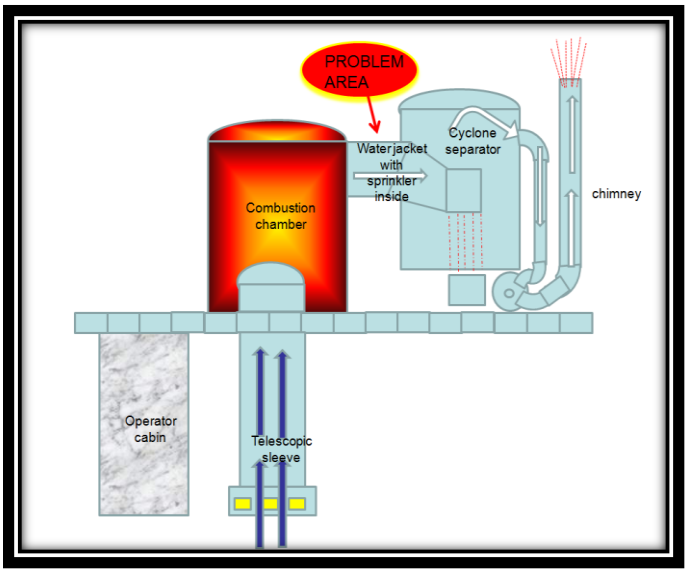


Fig 4

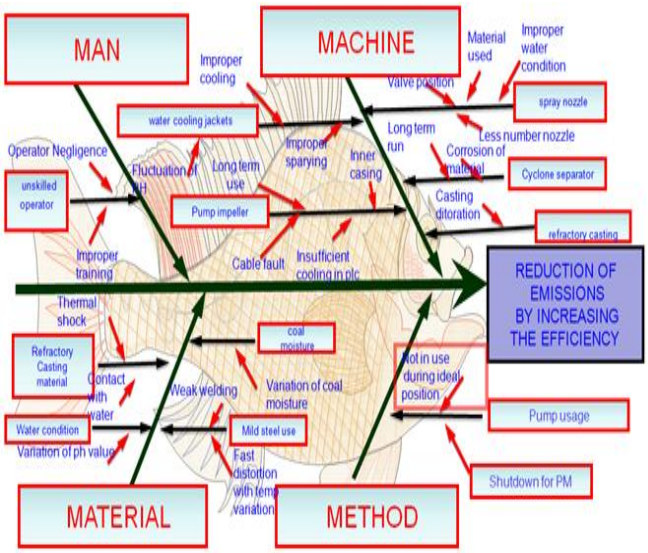
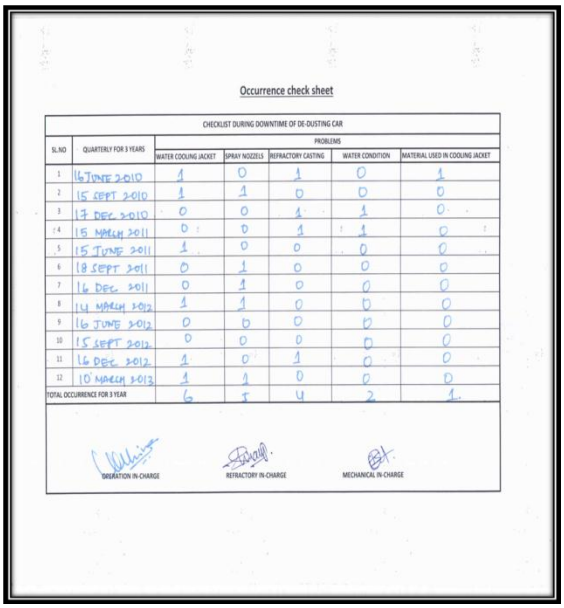


Fig 5. Root cause for emissions

Table -2



Occurrence check sheet

CHECKLIST DURING DOWNTIME OF DE-DUSTING CAR

Sl.No	QUARTERLY FOR 3 YEARS	PROBLEMS				
		WATER COOLING JACKET	SPRAY NOZZELS	REFRACTORY CASTING	WATER CONDITION	MATERIAL USED IN COOLING JACKET
1	16 JUNE 2010	1	0	1	0	1
2	15 SEPT 2010	1	1	0	0	0
3	17 DEC 2010	0	0	1	1	0
4	15 MARCH 2011	0	0	1	1	0
5	15 JUNE 2011	1	0	0	0	0
6	18 SEPT 2011	0	1	0	0	0
7	16 DEC 2011	0	1	0	0	0
8	14 MARCH 2012	1	1	0	0	0
9	16 JUNE 2012	0	0	0	0	0
10	15 SEPT 2012	0	0	0	0	0
11	16 DEC 2012	1	0	1	0	0
12	10 MARCH 2013	1	1	0	0	0
TOTAL OCCURRENCE FOR 3 YEAR		6	5	4	2	1

OPERATION IN-CHARGE | REFRACTORY IN-CHARGE | MECHANICAL IN-CHARGE

Occurrence Check sheet of material & machine related problems.

IV. Data Analysis On The Root Cause

From the validations; ***machine and method*** related causes which did not satisfy the standard were checked in a battery and an occurrence chart was prepared as shown in table10.

Table 3

Sl.No	PROBLEMS	Occurrences in history record
1	water cooling jacket	6
2	spray nozzles	5
3	refractory castings	4
4	water condition at inlet	2
5	material used in water cooling jacket	1

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Based on the available data from occurrence chart a Pereto Chart was prepared as shown below in fig from which we concluded that these three causes water cooling jacket, spray nozzles, refractory casting Were responsible for the emissions from De-dusting car and contributing up to 80% of the problem.

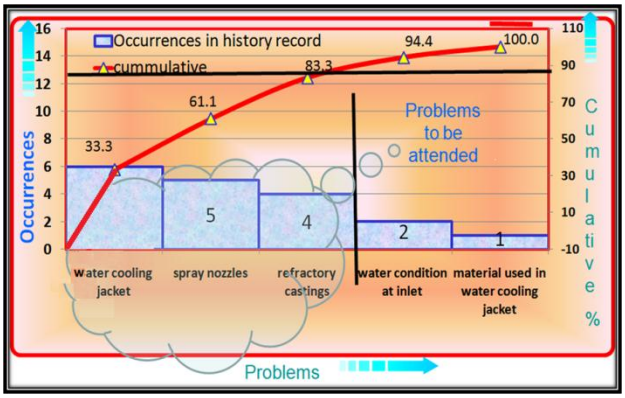

Fig -6 occurrences

V. DEVELOPMENT OF SOLUTION

Aim: To overcome the water jacket damage by increasing the cooling effect through modification.

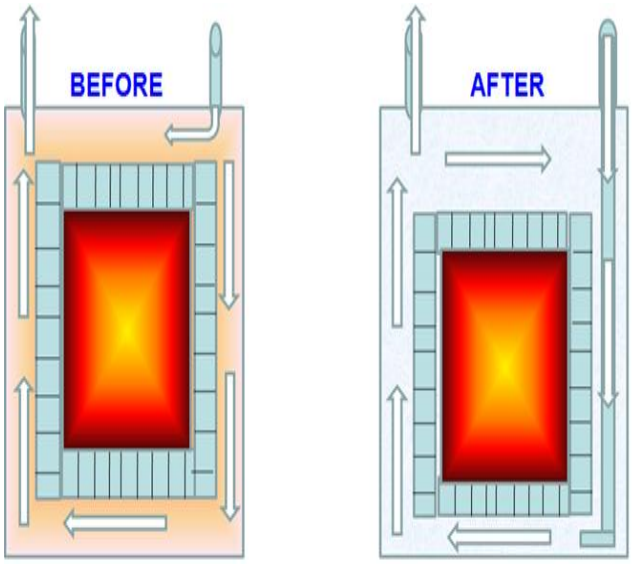

Fig -7 water jacket

1. *Solution:* the volume of cooling jacket is increased.

   Remarks: The volume increases naturally the water cooling retaining time increases hence the water jacket is protected from temperature deviation but high investment factor.

   Conclusion: So the solution was rejected.

2. *Solution:* the renovation of the all the duct line with SS plate.

   Remarks: The SS sheet is high resistance to the temperature variation also the life span is better than MS iron but the long shutdowns and huge cost are demerits.

   Conclusion: So the solution was rejected.

3. *Solution:* valve replacement of de-dusting car when where it has been choked.

   Remarks: this was the unconditional problem which is not frequently causes for water cooling jacket distortion.

   Conclusion: So the solution was rejected.

4. *Solution:* Increase in volume only on top of cooling chamber and inlet pipe extended inside the water cooling jacket thus the circulation process is free and cooling "retaining time" is increased.

   Remarks: This looked like a possible solution and can be achieved.

   Conclusion: So the solution was accepted.

Aim: To increase the spray nozzle for formal cooling & effectiveness inside duct line.

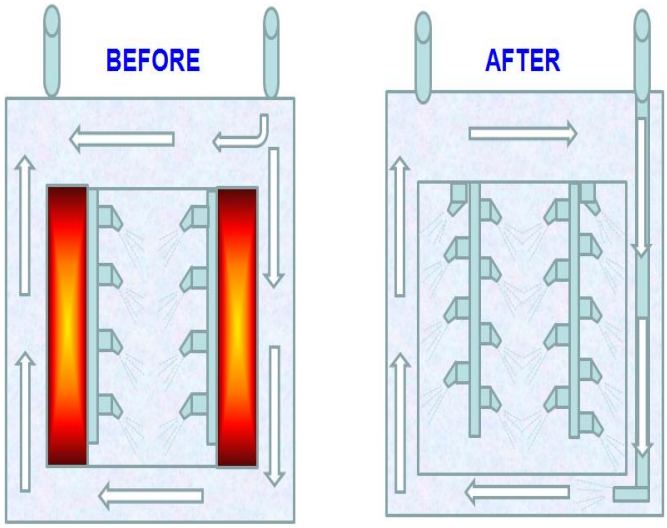

Fig -8 nozzle increases

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1. *Solution:* spray nozzle is increased by more than 25nos.

   Remarks: the cooling effect is increased by increase in spray nozzle but area inside the duct line is not sufficient for above 15nos.

   Conclusion: So the solution was rejected.

2. *Solution:* increase in volume of duct line.

   Remarks: so the number of spray nozzle can be implemented for above 25nos but that required long shutdown and investment.

   Conclusion: So the solution was rejected.

3. *Solution:* implementation of extra pipe line for circulation of water for spray nozzle.

   Remarks: This increase the propagation of cooling effect at the cooling jacket but extra pipe line is against the design and investment character.

   Conclusion: So the solution was rejected.

4. *Solution:* Increase the spray nozzle from 8 to 14 nos. at the direction of wall of jacket and the two extra nozzles from the tapping of the water jacket.

   Remarks: This looked like a possible solution and can be achieved.

   Conclusion: So the solution was accepted

Aim: To achieving better option of the refractory casting.

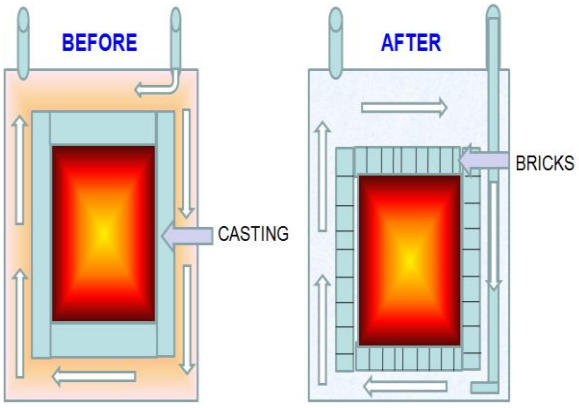

Fig-9 casting

1. *Solution:* double casting over the cast able material.

   Remarks: This will protect from the heavy thermal shock and deviation of the temperature but this adds extra work and manpower involved.

   Conclusion: So the solution was rejected.

2. *Solution:* changing the design parameter of the casting.

   Remarks: replacing of casting material with high grade ceramic brick which will protect from all deviation naturally the performance increases.

   Conclusion: So the solution was accepted

3. *Solution:* Changing the casting material

   Remarks: This will definitely increases the durability and performance of refractory life span but this also increases investment.

   Conclusion: So the solution was rejected

PLAN:-

1. Cooling jacket volume to be increased at top section of duct.
2. More water spraying nozzle with defined direction.
3. Replacement of SS sheet inside the duct line over MS.
4. Replacement of Refractory material from casting to Al2O3 bricks.

The activities were executed according to the plan.

- ***When we are in the third stage of PDCA cycle following observation Found*** The water cooling jacket temperature got reduced from 250 c to 95 c and emissions reduced.
  Significant improvement found.

Further Observation also showed the following

- There is emission found during start of coal cake charging.

Fig 10 stack emission

Emissions found during start of charging after foot pressing so for this problem we did Why Why analysis for find the problem

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Why analysis was done to find the root cause

Emissions found during start of charging.

Why?

The pressure applied for foot pressing is insufficient.

Why?

The loose coal on the top cake required another procedure.

Why?

Because the blower suction pressure is more.

Why?

It's the design parameter of the blower.

What is the solution?

Implementation of "RAMMER" to stamp the loose coal which is found on top layer of the cake made.

Fig -11 after results

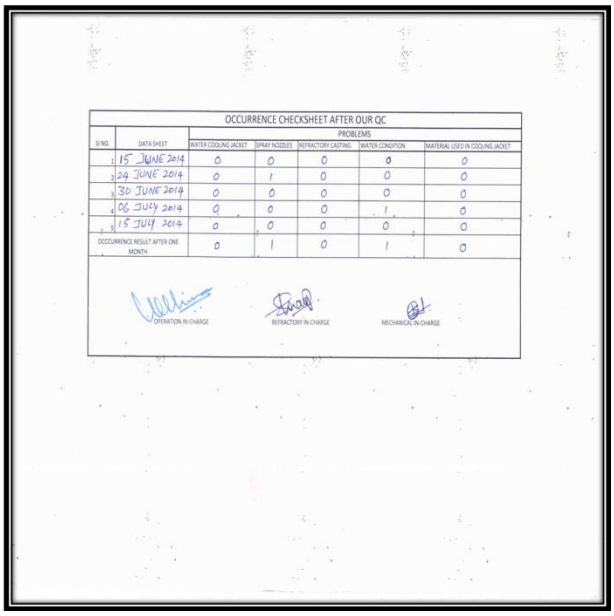
This occurrence chart is the comparison of before & after our project which clearly show all the problem have been uniformly distributed as seen in table 8.3.

Table 3

Sl.No	PROBLEMS	Occurrence Before	Occurrence After
1	Water cooling jacket	6	0
2	Spray nozzles	5	1
3	Refractory castings	4	0
4	Water condition at inlet	2	1
5	Material used in water cooling jacket	1	0

This is comparison of occurrence is shown below.

Table 4


OCCURRENCE CHECKSHEET AFTER OUR QC

Sl NO.	DATA SHEET	PROBLEMS				
		WATER COOLING JACKET	SPRAY NOZZLES	REFRACTORY CASTING	WATER CONDITION	MATERIAL USED IN COOLING JACKET
1	15 JUNE 2014	0	0	0	0	0
2	24 JUNE 2014	0	1	0	0	0
3	30 JUNE 2014	0	0	0	0	0
4	06 JULY 2014	0	0	0	1	0
5	15 JULY 2014	0	0	0	0	0
	OCCURRENCE RESULT AFTER ONE MONTH	0	1	0	1	0

OPERATION IN CHARGE REFRACTORY IN CHARGE MECHANICAL IN CHARGE

VI. TRIAL AND IMPLEMENTATION

After overcoming all the probable resistance; we started to work on how & where to increase the life span of water cooling jacket, through trial and implementation.

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During the process of trial and implementation we used PDCA cycle and took various trials among which few of the following were.

For appropriate efficient temperature of water cooling jacket.

Trail 1:- Water is being circulated to the vertical nozzles in the same direction of the gas.

Remarks: - Required Reduction of outlet gas temperature was not achieved, the water was not circulated in horizontal nozzles.

Conclusion: - Trial rejected.

Trail 2:- the water is being sprayed to both vertical horizontal nozzles.

Remarks: - Required reduction in outlet gas temperature was improved.

Conclusion: - Trial success.

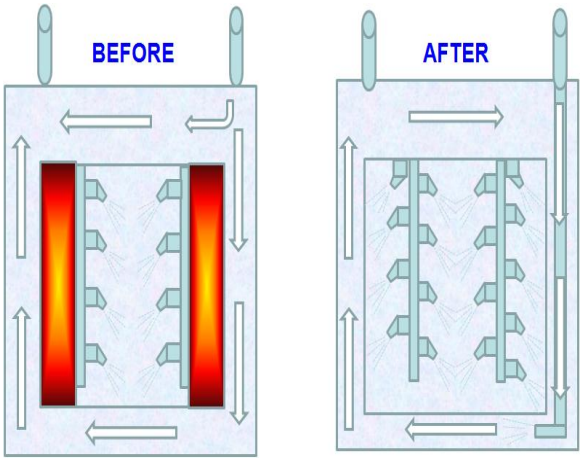

Fig 12 nozzles

For appropriate reduction of emission at start of charging.

Trail 1:- Implementation of single rubber pad after the cake made and stamping to be done on it for avoiding the loose coal.

Remarks: - This implementation has increased the cake making time which has got opposition from top management.

Conclusion: - Trial rejected.

Trail2:- Use of "RAMMERS" after the cake making.

*Remarks:-*The extra time and emission reduced by implementation.

Conclusion:- Trial success

Fig – 13

Stamping on belt rubber on cake leads to increase in stamping time so RAMMER is implemented to improve the stamping time and also to reduce the loose coal on top of cake made.

These are following regular implementation which we introduced:

1. Periodic observation of temperature at water cooling jacket to be done.
2. Monthly inspection of brick lining of duct line to be done.
3. Regular checks to be done on spray nozzles for further improvements.
4. Observations to be done on deformation on the duct line.

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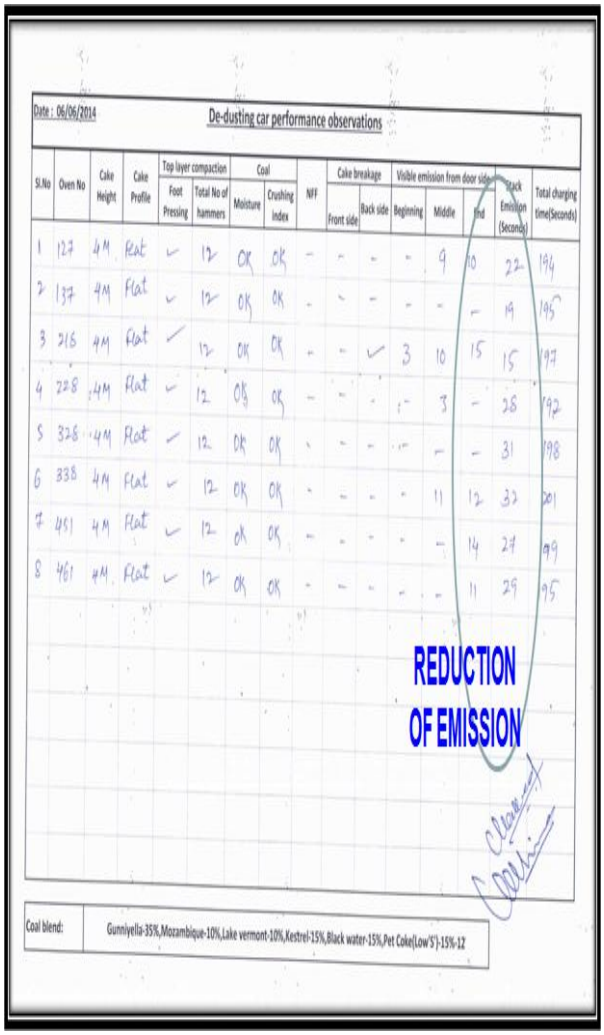
Picture shows the comparison of before and after our project.

Table 5



Cost Reduction By This Project

Table 6

BEFORE PROJECT					
SI NO.	ONE DE-DUSTING CAR PER S/D	DOWN TIME-6 DAYS			
1	REFRACTORY MATERIAL & MANPOWER	CASTING	3 tons*24,000	INR 48,000	(a) BEFORE QC =2017800
		V' Anchor	300 pieces*70	INR 21,000	
		MAN POWER-10 NO'S	10*360	INR 3,600	
2	MECHANICAL MATERIAL & MANPOWER	MATERIAL	3 tons*65000(including fabrication & errection)	INR 195,000	
		MAN POWER-10 NO'S	10*300	INR 3,000	
3	MAINTENANCE COST PER S/D	TOTAL COST per annum		INR 249,600	
4	YEARLY TOTAL COST FOR 4 BATTERIES	**8 S/D PER YEAR**		**INR 2,017,800**	
AFTER PROJECT					
SI NO.	ONE DE-DUSTING CAR PER S/D	DOWN TIME-3 DAYS			
1	REFRACTORY MATERIAL & MANPOWER	BRICK LINING	300 bricks*130	INR 39,000	(b) AFTER QC =975600
		mortar	3 bags * 700	INR 2,100	
		Hysil board	2.5sq meter*950	INR 2,400	
		MAN POWER-10 NO'S	10*360	INR 3,600	
2	MECHANICAL MATERIAL & MANPOWER	MATERIAL	3 tons*65000(including fabrication & errection)	INR 195,000	
		MAN POWER-6 NO'S	6*300	INR 1,800	
3	MAINTENANCE COST PER S/D	TOTAL COST per annum		INR 243,900	
4	YEARLY TOTAL COST FOR 4 BATTERIES	**4 S/D PER YEAR**		**INR 975,600**	

TOTAL COST SAVING PER YEAR (a-b) = 20,17,800-9,75,600
=10,42,200 Rs/annum

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Comparision Of Spary Nozzle Before And After Our Project

1. Reduction in shutdown time from 6 days to less than 3 days.
2. Visible stack emissions of de-dusting car reduced from 80 sec to less than 30 sec
3. Increase in life span of the de-dusting car from 6 months to more than 1 and half year.
4. Manpower involved reduced from 20 nos. to 9 nos.

Tangible Benefits:

By reduction of downtime in de-dusting the following benefits were obtained

1. Reduction in shutdown time from 10 days to less than 6 days.
2. Visible stack emissions from de-dusting car are less than 30 sec.
3. Increase in life span of the de-dusting car from 6 months to 1 and half year.

Intangible Benefits:

I have learned, analyzing and problem solving using Quality tools. Our confidence level, co-ordination, time management and presentation skill has improved. We learned to work as a team and put our thoughts into actions. Failure is not the last step but is a step to success. From Environment Aspect: Reduce dust emission, thus creating environment friendly work area. On Housekeeping front: Improved housekeeping by reducing fines generation and creating safe area to work. In Safety Accept: Developed clean and safe working environment.

VII. Conclusion & Scope For Future Work

By reduction of downtime in de-dusting the following benefits were obtained

- Reduction in shutdown time from **6 days to less than 3 days**.
- Reduction in capital repair cost for renovation from **0.71Cr to 0.12 Cr** per year
- A visible stack emission from de-dusting car is **less than 25 sec**.
- Increase in life span of the de-dusting car from **6 months to 1 and half year.**

Future Scope:-

- De-dusting car emission reduction from 25 sec to less than 10 sec by same technique and with variation in SOP of De-dusting car.
- Emission reduction while coal cake charging inside the oven.

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