# Reduction of un-burnt in bottom ash of coal fired boilers

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## Abstract

In a recent updating world moves related to automation and its improvements but only thread to pause to its electricity. Because it could not be automated and its need to be generated by using different way of methods. In that the Electricity is one the greatest demands that keeps increasing day by day. To feed its supply the necessity of improved power generation techniques is in need. Combustion of coal is one of the traditional methods of producing electricity in developing countries like India. So, it is necessary to have a good optimized boiler to generate power in thermal power plants. The coal fed in should be completely utilized for combustion as the coal is imported at a high rate. But the amount of un-burnt carbon found in the bottom ash slips down the efficiency of a boiler. Here we are going to analyses the causes for more number of un-burnt in bottom ash and methodology to reduce it thereby the efficiency of the boiler gets increased.

## 1. Introduction

Efficiency attains its maximum value when the fuel supplied is fully utilized for Boiler the fuel supplied should be burnt completely. In NTPL more amount of un-burnt carbon is seen in the bottom ash of unit -2. This loss is really a heavy loss as the coal used here is imported and a huge amount is spent on it. Getting the coal at a high rate and if the coal fails to burn completelythen it is definitely an inability of efficient system. So the samples of bottom ash were collected and the percentage of un-burnt carbon was tabulated for both units 1 and 2.

**Table 1:** Un-burnt Carbon bottom ash of NTPL

| DATE | ALLOWABLE VALUE % | UNIT 1 % | UNIT 2 % |
|------|------|------|------|
| 08/12/17 | 1.0-1.6 | 1.83 | 3.16 |
| 09/12/17 | 1.0-1.6 | 1.69 | 2.72 |
| 11/12/17 | 1.0-1.6 | 1.74 | 2.86 |
| 12/12/17 | 1.0-1.6 | 1.56 | 2.81 |
| 13/12/17 | 1.0-1.6 | 1.98 | 3.04 |
| 14/12/17 | 1.0-1.6 | 1.78 | 3.51 |

The table readings itself indicates that the amount of un-burnt carbon that is found in the bottom ash of Unit 2 Boiler is in high value than allowable norms.

In boilers about 80 percent of the ash in the coal being fired is carried as flash. The other about 20 % gets collected as bottom ash. During the combustion of coal, some portion of the hydrocarbon, mainly char, leaves the furnace as unburned particles. The amount of such unburned particles leaving the furnace depends on many factors like coal property ,the type of burning system , the resident time available in the furnace , the ash percentage in coal , the calorific value of coal , the air fuel ratio , operating conditions (SADC,Burner TILT & Wind box DP ) etc. The existence of unburned carbon in ash decreases the combustion efficiency Analysis of un-burnt carbon can be determined by following observations in the mill and firing system.
1) Mill outlet conditions
2) Roller gap and Spring tension
3) Wind box pressure Differential pressure
4) Burner tilt position
5) Classifier setting in mills

## 2. Mill Outlet Condition

There are 2 primary air fans used for drying and carrying the pulverized fuel to the burners through coal pipes. The primary air fan outlet is divided in to two ducts namely1. Tempering air duct and 2. Cold air duct. The cold air passes through APH and form hot PA duct. The hot and cold tempering air are mixed together and supplied to the mill to maintain the mill outlet temperature. The temperature at mill outlet is to be maintained 60 to 70 deg c by controlling the hot and cold air dampers. If the mixed air pressure is not maintained sufficiently, coal could not be carried to the burner properly, it also leads to for un-burnt carbon in ash.

## 3. Roller Adjustments

The pulverizes are bowl and roller type. There are 3 rollers rotating along with the bowl by the friction. For pulverizing the coal there are 8 mills available. These mills are of bowl type having the capacity of 55 t/hour. Each mill consist of 1 turn table and 3 rollers with suitable drive mechanism for rotating the table. All the rollers are positioned on the table such a way that they are free to rotate on the table by exerting some pressure. For exerting pressure 3 preloaded spring assemblies are used for one for each roller. While running the mill coal is being crushed between the

roller and bowl and are moved to furnace by primary air. For getting the proper fineness the gap between the roller and turn table is maintained around 6-8 mm. This is being adjusted periodically due to the wear of roller .

The springs in the spring assemblies are compressed in such a way that they exert pressure to get a fineness of about 70 % pass through 200mesh. Previously the spring tension was kept around 9.5 tons and for better fineness this has been raised to 11 tons.The heavy foreignmaterials due to the centrifugal force moves to the reject box via scrapper. This fineness of coal leads a main roll for the presence of un-burnt carbon in ash.

## 4.  WindBox Differential Pressure

In tangential and corner firing concept, the furnace itself constitutes the burner. Fuel and air nozzles in thecorners are pointed in a line, tangent to an imaginary circle at the center of the furnace. The result of this arrangement is a rotating swirling action that is very effective in mixing the burning fuel with secondary air.The total combustion air flow supplied in the boiler consists of two parts, one, the primary air, which is used for drying and transporting the coal from the pulverizer through the coal piping into the furnace and is supplied by the primary air fans and two, the secondary air sent through the four corners of the wind box and is supplied by the FD fans. The total secondary air flow is controlled by forced draft fan, in proportion to the fuel beingfired. Total air secondary flow is measured by a flow metering device called aero-foil in both sides of wind box.

Secondary air distribution at required elevation is very important. Avoid/reduce all unwanted secondary air distribution at any location which improves the windbox differential pressure.

To get better flame intensity and stability, optimum wind box DP and reducing the opening of FAD (Fuel Air Damper) is suggested. The measured air flow is compared against the fuel flow, with the resultant signal positioning the FD fan inlet guide. This inlet guide is positioned to maintain the required air flow regardless andindependent of secondary air damper position.In the boiler there are 2 wind box provided at left and right side of the furnace wall in which the left side wind box supply air to the burner blocks of corner 1 and 2 and the right side to corner 3 and 4.The hot secondary air from FD fan via air preheater is stored in the windbox. The pressure in the windbox shall be maintained by the FD fans with respect to the total air flow demand. The differential pressure across the windbox and the furnace is to be maintained for proper turbulence in the burner. The secondary air dampers located at respective coal burners and oil burners will modulate in such a way for complete combustion of the fuel. Auxiliary air dampers also provided for excess air supply and to control the windbox DP.
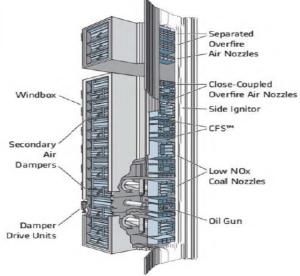


**Fig. 1:** Windbox and SADC

## 5.  Burner Tilt

Burner tilting mechanism is done in the boilers to raise or lower the flame (fire ball) to control the steam temperature apart from steam temperature control.  This is a mechanical arrangement in which all the burners on the four corners are tilted simultaneously. Normally the position of the burner is at datum and feasible for moving up and down (+/-) depends upon the requirement.  It is useful in uniform burning of the fuel. If any one or more corner is behaving erratically there will be no uniform combustion and resident time of the fuel. If any of the tilt position is minimum / -ve due to some mechanical defects the resident for the fuel injected through that burner may result increase in un-burnt carbon in bottom ash. So burner tilt plays an important role in combustion zone.



**Fig. 2:** Burner Nozzle

## 6.  Classifier Setting in Mills

Classifiers are present on the upper area of mills. The pulverized coal from the mill is carried by the primary air to the classifier. Classifier consists 40 nos. of blades which segregates the coal particles based on size. It creates the rotating motion on coal air mixture. Through this motion, larger particles are centrifuged and settled down for re-grinding.  If the blades stay away from each other leaving a big gap between, then coarser particles may enter into the burner and it may produce un-burnt in big terms. The fine particles from the mill discharge valves are taken to the burner through coal pipes.



**Fig 3.** Classifier Blades

## 7. Control Unit Readings

The allowable amount of un-burnt in bottom ash lies within 1.6% for the coal of GCV 3680 kcal/kg in NTPL. But the amount of un-burnt in unit 2 boiler always sticks its value nearer to 3%. So inorder to find if any errors are present in the air supply, coal flow and temperature, the following readings were checked and they were found under allowable conditions in the CONTROL UNIT of boiler 2 for various loads.

## 8. Un-Burnt in Unit 2 Boiler

The bottom ash samples were taken and was tested for the amount of un-burnt carbon present in it from 08/12/2017 to 14/12/2017. There was a great deviation in the percentage of un-burnt found in the bottom ash. Every small amount of carbon loss causes heat loss in the boiler. For 1% of un-burnt carbon nearly 1.989 kcal of heat is lost and if 1 kcal of heat is lost then the loss occurred in improper utilization of coal is Rs 10,349. The amount of heatloss and the financial loss caused by it are tabulated.

**Table 2:** Boiler 2 Losses

| DATE | ALLOWABLE VALUE % | ACTUAL VALUE % | HEAT LOSS (kcal/kWh) | FINANCIAL LOSS (INR/DAY) |
|---|---|---|---|---|
| 08/12/2017 | 1.0-1.6 | 3.16 | 6.285 | 65,043 |
| 09/12/2017 | 1.0-1.6 | 2.72 | 5.162 | 53,421 |
| 11/12/2017 | 1.0-1.6 | 2.86 | 5.688 | 58,865 |
| 12/12/2017 | 1.0-1.6 | 2.81 | 5.589 | 57,840 |
| 13/12/2017 | 1.0-1.6 | 3.04 | 6.046 | 62,570 |
| 14/12/2017 | 1.0-1.6 | 3.51 | 6.981 | 72,246 |

Based on this observation the following changes and adjustments were carried out to minimize the un-burntcarbon in the bottom ash in order to reduce the losses in the boiler.In the pulverizer PFsamples were taken before adjusting the roll gap and similarly readings were taken after adjusting the mill roller gap value of 10mm to 6 mm. Comparing the above two samples after reducing the roll gap pulverized coal fineness is improved.

1. The Classifier blade position was shifted to 7 which was previously in 10. So that certain coarse particles can stay back from entering the furnace and can be pulverized again to achieve required fineness.
2. The burner tilt arrangement at all the four corners were checked and found some of the elevations irrespective of corners were found not matching with the other corners. The same was adjusted mechanically and kept the tilt position to positive side. By this change in tilt position the resident time of the fuel increased and complete combustion takes place before reaching the bottom hoppers
3. All SADC were checked and found most of the actuators were not operating proportionately with respect to the command from DCS and few of the actuator links were found disconnected. The faulty and damaged actuators were made ready andcalibrations was done with the help of controls and instrumentation. After attending the faulty actuators a considerable amount of wind box DP was improved.
4. The differential pressure in air preheaters were found high which leads to less heat transfer to primary and secondary air was improved by suggesting that the existing RAPH soot blower operation once in a day is changed to operate twice in a day. By this the differential pressure in the flue gas is reduced and primary air and secondary air temperature is increased which helps proper thermal grinding in the mill and good combustion respectively.
5. The spring compression value was changed from 9.3 tons to 11.3 tons to achieve the required pulverized fuel fines.

After doing all the above changes in operating system, bottom ash samples were taken from Boiler-2 and sent to lab for testing. The obtained values of un-burnt carbon in bottom ash along with the amount of heat loss due it and the financial loss occurred due to the heat loss in boiler-2 are tabulated below.

| DATE | ALLOWABLE VALUE % | ACTUAL VALUE % | HEAT LOSS (kcal/kWh) | FINANCIAL LOSS (INR/DAY) |
|---|---|---|---|---|
| 21/12/2017 | 1.0-1.6 | 1.68 | 3.341 | 34,576 |
| 22/12/2017 | 1.0-1.6 | 2.05 | 4.077 | 42,192 |
| 23/12/2017 | 1.0-1.6 | 1.86 | 3.699 | 38,280 |

## 9. Conclusion

A detailed study and analysis of un-burnt carbon in bottom ash was done and the methods to reduce un-burnt carbon were discussed and implemented which not only increases the efficiency of the boiler but also saves a huge amount, nearing a crore per year for NTPL

## References

[1] Ren Jianxing, Li Fangqin, Zhu Qunzi, Wu Jiang, Yang Yongwen, Liu Qingrong, Liu Hongfang, "Research of Multi-Fuel Burning Stability In A 300MW Coal-Fired Utility Boiler", Energy Procedia, Volume 17, Part-B, 2012,Pages 1242-

[2] Tharayil James Joseph, B.A. Shah, D.M.Jethva,"Optimization of Combustion in Pulverized Coal Fired Boiler", International Journal of Advances in Production and Mechanical Engineering, ISSN: 2394-6202, Volume-1, Issue-6, 2015,

[3] Brundaban Patro, "Efficiency studies of combination tube boilers", Alexandria Engineering Journal, Volume 55, Issue1, March 2016,Pages 193-202.

[4] Lu Junfu, Wang Qimin, Li Yong, YueGangxi, Yam Y. Lee, Baldur Eliasson, ShenJiezhong, Yu Long," Unburned Carbon Loss in Fly Ash of CFB Boilers Burning Hard Coal",ISSN 1007-0214 , Volume 8 ,Number 6, December-2003.

[5] Chetan T. Patel1, Dr.Bhavesh K. patel, Vijay K. Patel, "Efficiency with different GCV of coal and efficiency improvement opportunity in boiler", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2 ,Issue 5, May 2013,ISSN: 2319-8753.

[6] Sangeeth G.S, Praveen Marathur, "Efficiency Improvement of Boilers", International Research Journal of Engineering and Technology, Volume: 02 Issue: 05, Aug-2015,ISSN: 2395 -0056.

[7] MoniKuntal Bora, S. Nakkeeran, "Performance Analysis fromthe Efficiency of Coal Fired Boiler", International Journal of Advanced Research (2014), Volume 2,Issue 5,561-574

[8] Sharukh khan, Shahabazkhan,"Boiler and its Tangential Fuel Firing System", International Journal of Automation and Control Engineering, Volume 3 Issue 3, August 2014.

[9] Saeid R. Dindarloo, James C. Hower,"Prediction of the Unburned Carbon Content ofFly Ash in Coal Power Plants", ISSN#1946-0198, Volume 7, 2015.

[10] G.Chockalingam et al, (2017) "Parametric analysis of 49 cm serpentineflow channel of polymer electrolyte membrane fuel cell for performance enhancement" International journal of innovative research in science & engineering technology Vol 3 (1),pp118-122.

[11] E.Vignesh et al, (2017) "Performance improvement of pollution control device used in small scale industry" International journal of research in science & engineering Vol 3 (1),pp118-122

[12] T.Rajeshkumar et al, (2017) "Analysis of radiator coolant mixture using ethylene glycol and di ethylene glycol" International journal of innovative research in science & engineering technology Vol 3 (1),pp118-122.

[13] P Bala Gopal, K Hari Kishore, B.Praveen Kittu "An FPGA Implementation of On Chip UART Testing with BIST Techniques", International Journal of Applied Engineering Research, ISSN 0973-4562, Volume 10, Number 14 , pp. 34047-34051, August 2015

[14] T. Padmapriya and V.Saminadan, "Handoff Decision for Multi-user Multiclass Traffic in MIMO-LTE-A Networks", 2nd International Conference on Intelligent Computing, Communication & Convergence (ICCC-2016) – Elsevier - PROCEDIA OF COMPUTER SCIENCE, vol. 92, pp: 410-417, August 2016.

[15] S.V.Manikanthan and V.Rama" Optimal Performance Of Key Predistribution Protocol In Wireless Sensor Networks" International Innovative Research Journal of Engineering and Technology ,ISSN NO: 2456-1983,Vol-2,Issue –Special –March 2017.