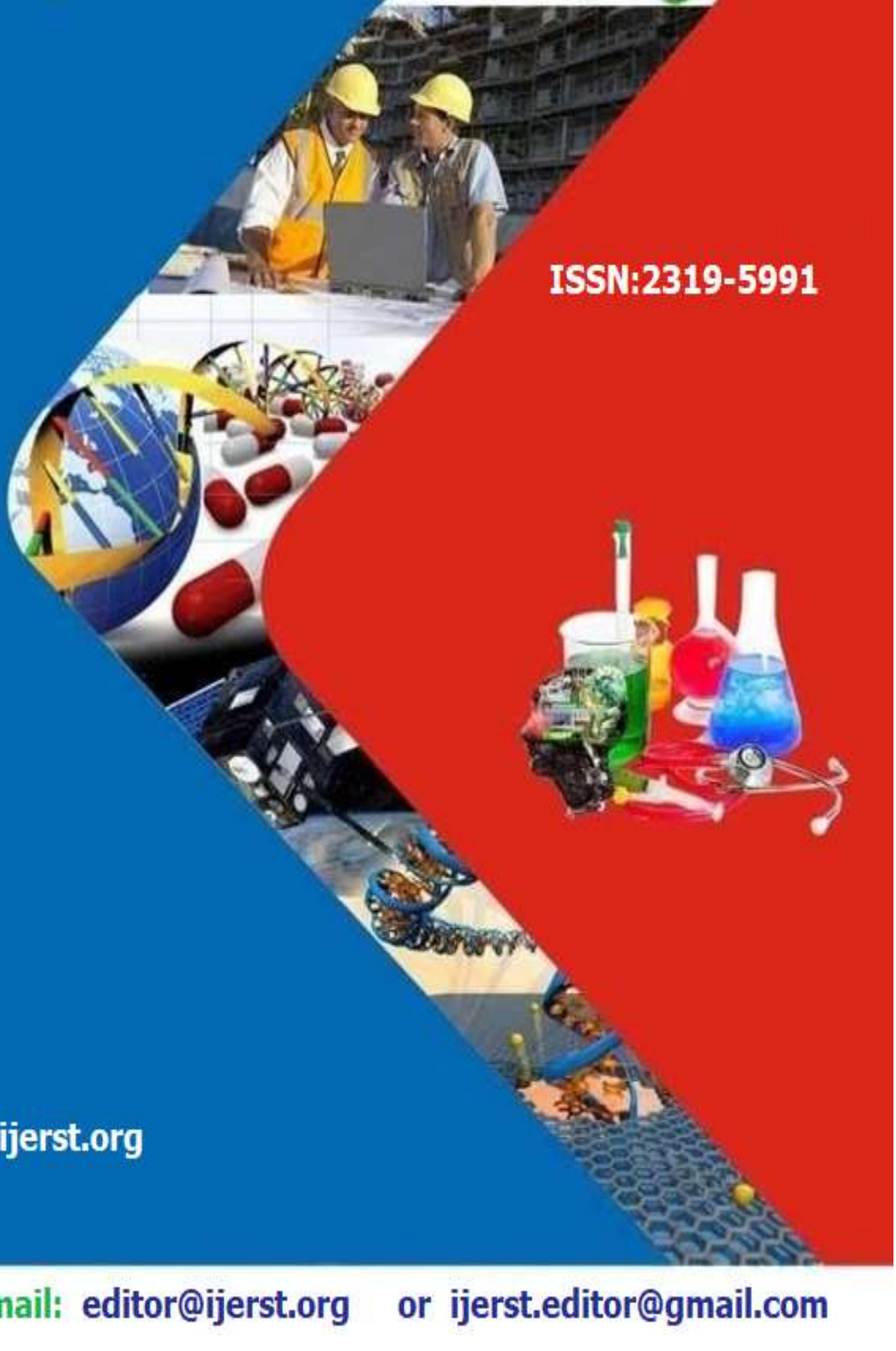
International Journal of Engineering Research and Science & Technology

IJERST

ISSN:2319-5991



www.ijerst.org

E-mail: editor@ijerst.org or ijerst.editor@gmail.com

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

Analysis and impact of high Ash content in pulverized Coal by using Six Sigma in Thermal Power Plant

S.Lingamaiah[1] Dr.R.Ramachandra[2]
[1]Research Scholar, BESTIU, Gorantla, Sri Satya Sai (District) India.
[2]Principal, , SKUCET,S.K.University Anantapuramu, India.

Abstract: In all over World production of power pulverized coal fired boilers are largely used. In India also 80% power is generated by pulverized coal fired boilers in National Thermal Power Plants. A very large quantity of ash is produced from these boilers. The quality of ash changing from plant to plant and from coke to coke based on resource of supply and method of combustion. In this research paper an attempt has been made to categorize problems and solutions related to it as given as for disposal of fly ash different types of ash ponds have been discussed. The effect of various type of ash/fly ash on air, land, water, agriculture living creature and human beings have been explained. And solutions are also suggested. Experimental effect of addition of polymer carboxy methyl cellulose in slurry have been identified to increase ash settling rates. And optimum ash settling rates 2ppm addition of carboxy methyl cellulose is sufficient. Utilization of fly ash for manufacturing of useful products has been mentioned.

Keywords— Coal, Fly ash, Settling time of ash, Ash utilization, Pulverization etc.,

1. INTRODUCTION

All over World production of power pulverized coal fired boilers are largely used. In India also 80% power is generated by pulverized coal fired boilers in National Thermal Power Plants.[1] A very large amount 200 million tons of ash is generated from thermal power plants. The quality of ash varies from plant to plant and from coke to coke depending on source of supply and type combustion. Fly ash is a very fine material formed by firing of pulverized coal in a thermal power plan. Fly ash is a common name used for the residual products of combustion that increase with flue gases. Flue ash (fly ash), it is one of the residues generated in combustion, and getting the fine particles that go up with the flue gases. In an industry, ash formed during combustion of coal. Flue gas carries fly ash and it is collected by the electrostatic precipitators or cyclones. Chemically and physically, fly ash having many forms like C-fly ash and F-fly ash depending upon the kind of fuel burned and handling methods. A typical fly ash contains a major amount of silicon dioxide and calcium oxide, which make it frictional and abrasive. Generally fly ash has a fine particle size distribution with most less than 100 microns. Given the fine particle size, frictional nature and high temperature, it is difficult material to handle reliably. Quantity poses difficult problems, in the form of getting land, health hazards, and environmental dangers [2].

In India coal based thermal power plants account for more than 55% of the electricity installed capacity and 65% of electricity generation. The ash content of the coal used at the thermal power plants ranges from 30-40%, with the mean ash content around 38%. Since low ash, high grade coal is reserved for metallurgical industries. The thermal power plants have to use high ash, low grade coal. The thermal power plants ash generation has increased from about 40 million tonnes during 1993-94, to 120 million tons during 2005-06, and is expected to be in the range of 300 million tons per year in 2024-25.

2. Literature Survey

Based on the resource and makeup of the coal being burnt, the composition of fly ash and bottom ash differ significantly. Fly ash

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

contains large quantities of silicon dioxide and calcium oxide which are the major ingredients of various coal bearing rocks. Coal Bituminous coals, sub-bituminous and lignite coals from various mines are significantly varies from each other in the combustion process. Coal blending uses for operational and economical benefits. This outcomes in a large range of boiler and precipitator operating conditions. Precipitating flue ash from hard coals can be improved with conditioning systems. Anyhow, the furnace and its related components may cause problems in the precipitator, mainly coal mills, burners, and air pre heaters. The operation of coal burners, together with the setting of the coal mills and their classifiers, effect the percentage of remaining unburned carbon(UBC) in the fly ash. The use of Lo NOx burners improves this percentage, and causes re-entrainment and develops sparks in the precipitator. Further, the UBC tends to absorb SO3, which in turn improves the fly ash resistivity. Harmful constituents of flue ash depends upon the specific coal bed makeup, but may consist of one or more of the following elements in quantities or trace amounts to different percentages: Arsenic, molybdenum, selenium, cadmium, boron, chromium, lead, manganese, mercury, strontium, thallium, vanadium, beryllium along with dioxins [3,4].

Two categories of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The primary difference between these classes is the amount of calcium, silica, alumina, and iron content in the fly ash. The chemical properties of the fly ash are basically influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite). Flue ash generated from the burning of younger lignite or sub bituminous coal, besides to having pozzolanic properties, also has little self-cementing properties. In the presence of water, Class C flue ash will freeze and gain strength during period of time. Class C fly ash normally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not needed an activator. Alkali and sulfate (SO4) contents are in general higher in Class C fly ashes. Class C fly ash can be recognised from its light brownish color. The burning of harder, older anthracite and bituminous coal typically produces Class F flue ash. This flue ash is pozzolanic in nature, and consists less than 10% lime (CaO). Exihibiting pozzolanic properties, the glassy silica and alumina of Class F flue ash needed a cementing agent, such as Portland cement, quicklime, or hydrated lime, with water in order to react and make cementitious compounds. Otherwise, the additions of a chemical activator such as sodium silicate (water glass) to a Class F ash can make the formation of a geopolymer. Class F fly ash can be recognized by its dark brownish color[4]. Traces of industrial pollutants has been find in isolated human, animal, and plant populations and also affect the environment in a large number of ways but also imparting negative impacts on human health and life.

The serious problems that arise from such dumping are

a. The making of ash ponds needs vast areas of land. This reduces land available for agriculture over a period of time.

b. When one ash pond filled, another pond to be constructed, at higher cost and more loss of agricultural land.

c. Large quantities of water needed to convert ash into slurry. Various salts and metallic contents in the slurry can reach down to the ground water and contaminate it, when rains come.

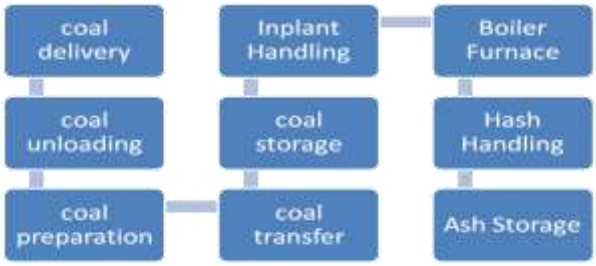


Figure-1 Coal and Ash Circuit

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

3. Identification of the Problem

Mainly, the flue ash is removed using either dry or wet disposal schemes. In dry disposal, the fly ash is carried by truck, chute, or conveyor at the location and removed by constructing a dry embankment (dyke). In wet disposal, the flue ash is carried as a slurry by pipe and removed in impoundment called “ash pond”. Ash ponds made at all coal based power plants except Dadri where Dry Fly Ash Disposal System has been given. Ash ponds have been partitioned into lagoons and provided with garlanding arrangements for change over of the ash slurry feed points for even filling of the pond and for effective deposition of the ash particles. Flue Ash in slurry form is getting into the lagoons where ash particles get deposited from the slurry and clear polluted water is removed from the ash pond. The removed effluents meet the standards mentioned by CPCB and the same is continuously maintained. Various factors which affecting land requirement for ash utilization, PLF (Plant load factor), height of dyke, shape and topography of land, substrata, land use pattern, seismic zone, coal parameters etc. Most of the power plants in India use wet disposal system and when the lagoons are full, Four basic options are available:-

a. Building new lagoons with the help of traditional construction material.

b. Carrying of fly ash from the existing lagoons to another disposal site.

c. Increasing the existing dyke using traditional construction material

d. Increasing the dyke using fly ash excavated from the lagoon (ash dyke).

The option of increasing the existing dyke is high cost because any flue ash used for constructing dyke would, in addition to saving the earth filling cost, improving disposal capacity of the lagoon. An prime aspect of design of ash dyke is the internal drainage system. The seepage flowing from the internal surfaces must be regulated with filters that permit water to flow freely and also to stick particles in place and the peizometric surface on the downstream of the dyke. The internal drainage system contains of construction of rock toe, 0.5 meter thick sand blanket and sand chimney. After finishing of the final section including earth cover the turfing is developed from sod on the downstream slope.

4.Methodology

Figure 2 Flow Chart of Methodology

5. Define:

In this phase problem statement defined and also identifies the importance of implementation of lean six sigma and minimization the variability in Ash content. In this phase define Critical success factors, which are Reduction in Ash content and its inventories, Improvement in heat rate due to reduction in Ash and Secondary benefits and periodically coal audit for continuous improvement.

6. Measure:

6.1Measurement of Carbon and Ash

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

The cover from the crucible used in the last test is removed and the crucible is heated over the Bunsen burner until all the carbon is burned. The residue is weighed, which is the incombustible ash. The difference in weight from the previous weighing is the fixed carbon. In actual practice Fixed Carbon or FC derived by subtracting from 100 the value of moisture, volatile matter and ash.

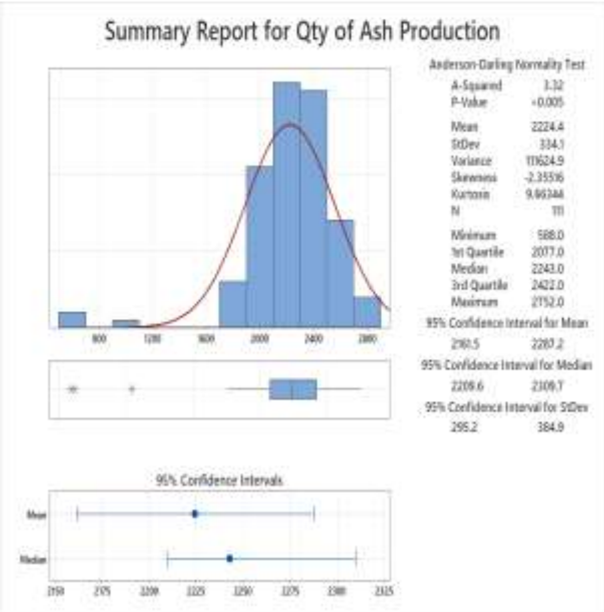


Figure 3

7 Analyse:

Firstly when we take data of four months Minitab 20 firstly trims value of top 5% and bottom 5% data. We see a squared value is 3.32. Graph is skewed to higher side positively skewed. Data is analyzed and causes of problem are discovered using following tools.

7.1 Run Chart:

Run chart was drawn from July 1st 2024 to 31st October data collected for day Ash production from Thermal Power Plant. From the results found using Minitab, P-values (Fig.4) for clustering (0.014), trend (0.145), oscillation (0.855) and mixtures (0.986) come out to be more than the significance level (0.05), indicating not any special cause of variation in data. If p value is more than 0.05 it means that distribution is normal.

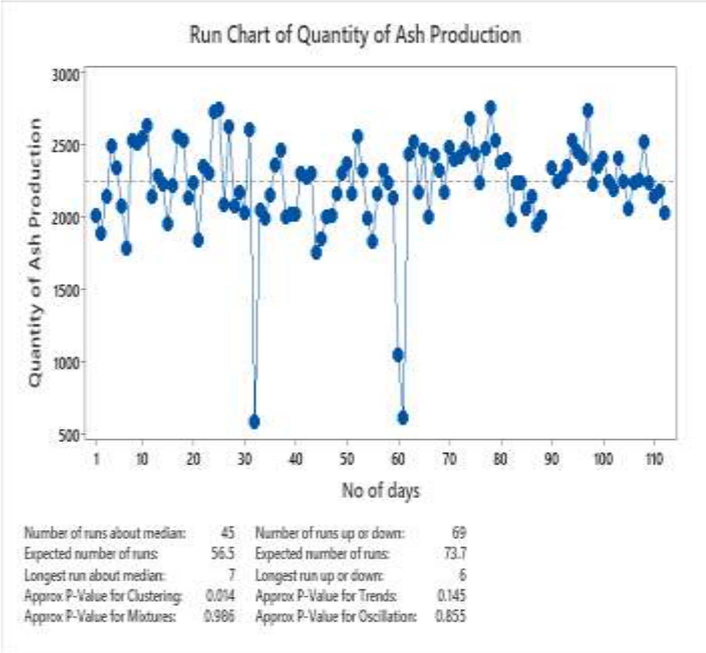


Figure 4

7.2 Process Capability analysis

Process capability analysis was performed using Minitab to draw curve for cycle make up water from TPP measured through flow meter (Fig.4) Z-bench sigma value of process was found to be 1.45 and existing DPMO level of the process comes out be 62500.00, which is remarkably high and shows that there are a lot of opportunities for improvement in the process. If we limit upper specification limit 2700tonnes and target value around 2000 tonnes.

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

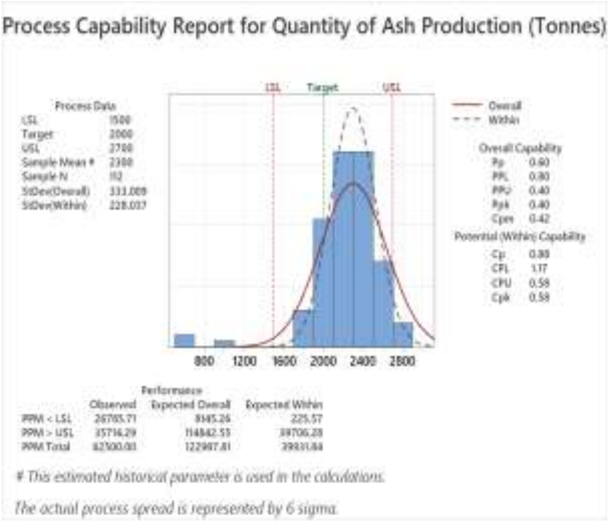


Figure 5

7.3 Fish-bone Diagram

Using expert experience and critical analysis of actual combined cycle at site, a fish bone diagram drawn (Fig. 7) to find causes of more Ash production during combined cycle.

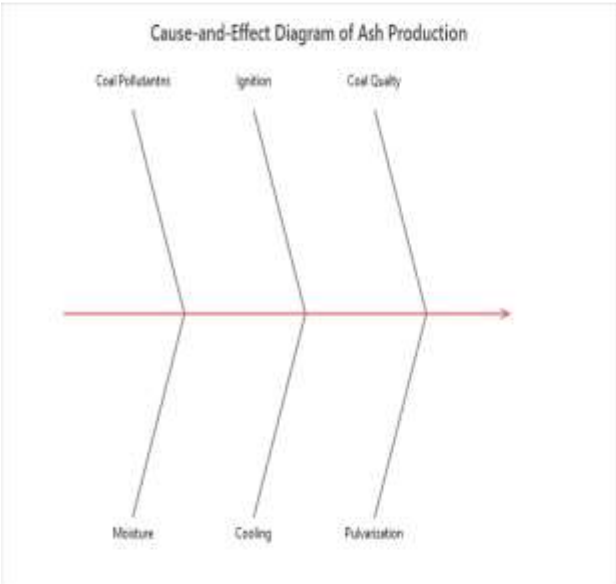


Figure 6

7.4 Bar Chart

Actual Ash production from different sites was measured or approximated where no measurement was possible. Based upon measurement results, bar chart was drawn and resultant causes with their percentage contribution were found to have biggest impact on Ash production.

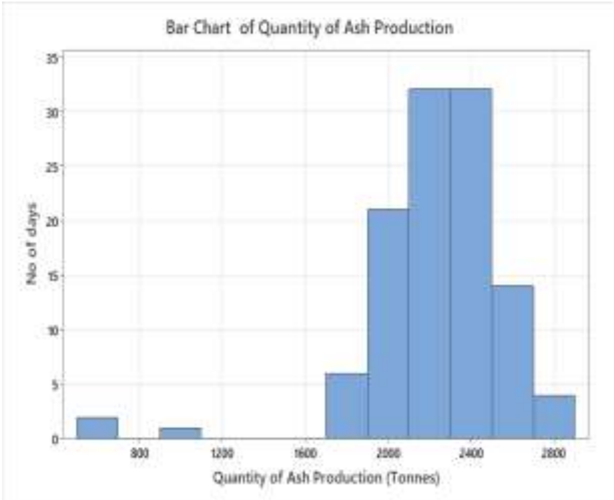


Figure 7

7.5 Pareto Chart:

Display Causes in order of decreasing frequency to prioritize improvement efforts.

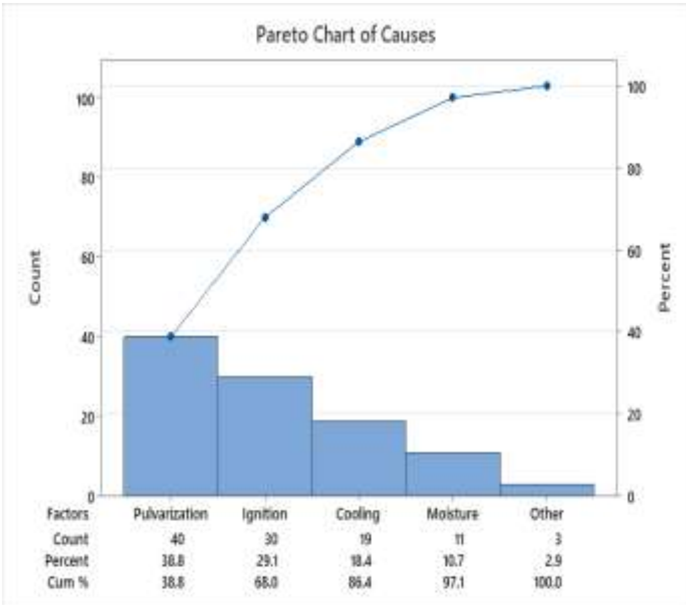


Figure 8

From the above analysis we find that Pulverization, Ignition, Cooling, Moisture are the main causes of the problem. Fly ash production reduces by regular check up and

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

training of lab analysts, and by reducing communication gap between chemical and operation staff casual approaches can be eliminated to find out solutions. For SDSTPS we consider following two things. First one is for any Stastical Quality Control we require UCL (upper critical level) and LCL(lower critical level) OEM gives us relaxation of 5%. We know our LCL can't be zero as power generation does not work on isolated system concept. Process is practically open system. So our goal statement converges to a band of Ash Production. So for calculation LCL we have used statics. Firstly we find the type of distribution which follows the Ash Production by using Minitab 20

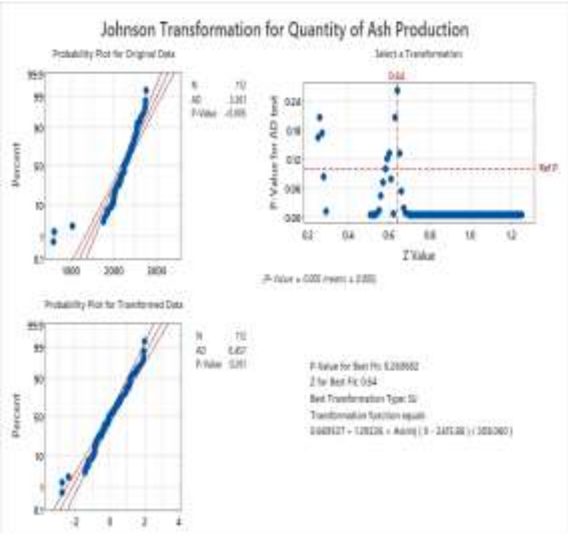


Figure 9

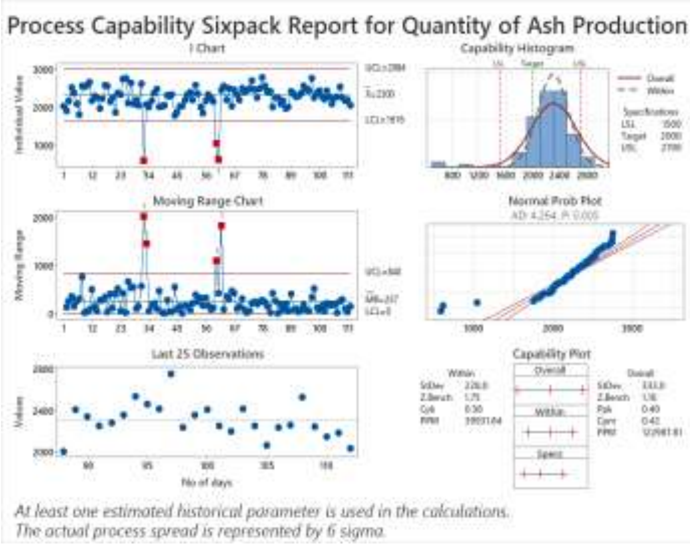


Figure 10

Test Results for I Chart of Qty of Ash Production

TEST 1. One point more than 3.00 standard deviations from center line.
Test Failed at points: 32, 60, 61

Test Results for MR Chart of Qty of Ash Production

TEST 1. One point more than 3.00 standard deviations from center line.
Test Failed at points: 32, 33, 60, 62

The greater the cpk value, the better. A Cpk value greater than 1 means that the 6 spread of the data falls completely within the specification limits. A Cpk of 1 means that one end of the 6 spread falls on a specification limits. Sigma level is 3 x cpk. A Cpk between 0 and 1 means that part of the 6 spread falls outside the specification limits.

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

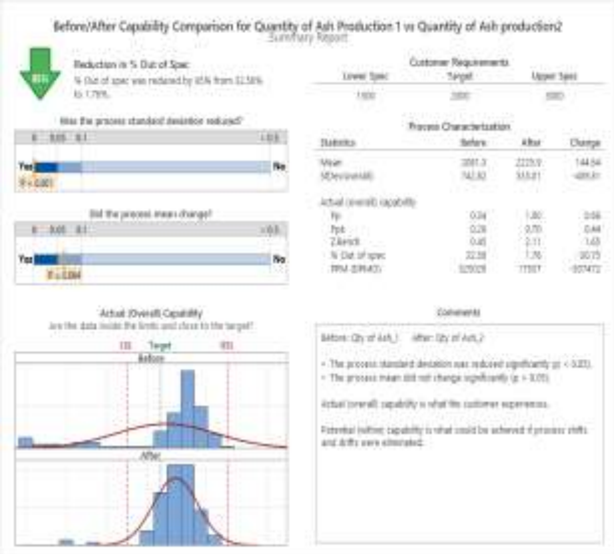


Figure 11

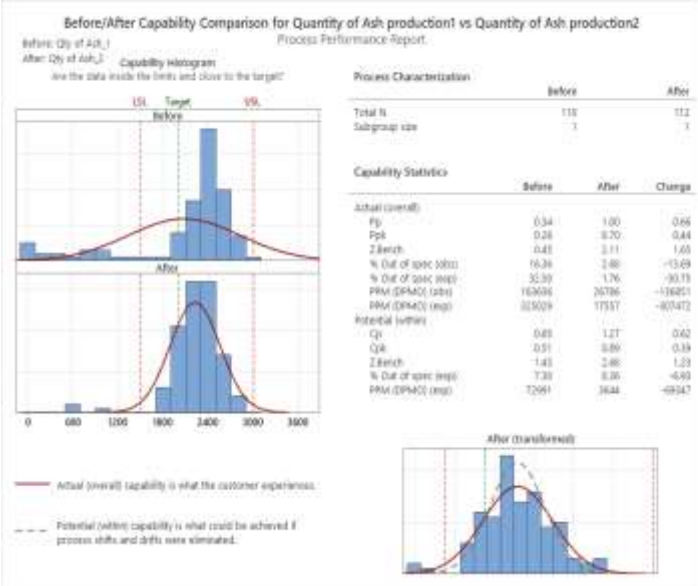


Figure 13

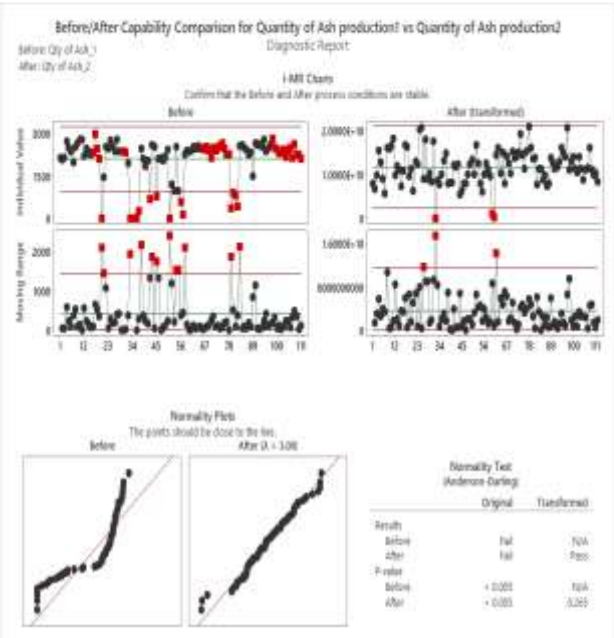


Figure 12

Figure 14

8. Control

In this stage, considerations of new process are documented and frozen into systems so that the gains are permanent. In anlysis phase all possible related causes of specific identified problem were solved.Regular inspection of all sources to be done on regular intervals. Pulverization of coal can performed so that ash production can reduces while combustion. Due to regular monitoring combustion we can control the generation of fly ash.. During overhauling, Boiler chamber can be checked for its erosion. Inspect electrostatic precipitators and filter fabric bughouses.

9. Results

Z Bench value of Ash production Before 0.45.
Z- Bench value of Ash production After 2.11
Application of project recommendation Ash production brought up the sigma level to 2.11 with DPMO level of 3644 (Reduction of 69347DPMO) and mean of the process

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

reduced to 2.68% (an improvement of 13.69%).

10. Conclusions

Study proves that firms successfully implement six sigma perform better in virtually every business category, including return on scales, return on investment, employment growth and stock value growth higher production of Ash production is found to be a big problem in a thermal power plant. The causes for more Ash Production are Pulverization, Ignition, Cooling, Moisture etc. Pulverization makes a big impact having 38% contribution for Ash Production. Further, some actions are recommended to reduce the production of Ash. Application of six sigma project recommendations brought up the sigma level to 2.11.

11. Scope for Research Work

Present process in Ash Production and its analysis suggest that there is a lot of scope of improvement in reducing Ash and variability. Cost of every additional ash production at any given plant depends on cost of Coal, chemical consumption, and heat energy loss. Our calculations suggest that every 1% reduction in Ash production at SDSTPS saves of 8 crore per year. Today our plants do not have system to carryout regular coal audits to identify sources and quantify and objective of our paper is to tell that importance of Ash reduction and its financial impact.

References

1. Akcin, G., Guldede, N. and Saltabas, O.: 1993, 'Zinc removal in strongly basic solutions by water hyacinth', *J. Environ. Sci. Health* **A28**, 1727–1735.
2. Balasooriya, I., Paulraj, P. J., Abeygunewardena, S. I. and Nanayakkara, C.: 1984, 'The Biology of Water Hyacinth: Physico Chemical Properties of the Water Supporting *Eichhornia crassipes* (MART.) Solms', in Thyagarajan, G. (ed.), *Proc. Internat. Conf. on the Water Hyacinth*, 7–11 February, 1983, UNEP, Nairobi, pp. 318–333.
3. Berrow, M. L. and Ure, A. M.: 1985, 'Trace element distribution and mobilization in Scottish soils with particular reference to cobalt, copper and molybdenum', *Environ. Geochem. Health* **8**, 19–24.
4. Bowen, H. J. M.: 1979, *Environmental Chemistry of the Elements*, Academic Press, London.
5. BSI (British Standards Institution): 1990, British Standard Methods of test for Soils for civil engineering purposes, Part 3, Chemical and electrochemical tests, BS1377:Part3:1990.
6. CPCB: 1993–1994, Central Pollution Control Board, Pollution Statistics Delhi, Delhi.
7. CPCB: 1994, Central Pollution Control Board, Annual Report 1993–94, Delhi.
8. Chigbo, F. E., Smith, R. W. and Shore, F. L.: 1982, 'Uptake of arsenic, cadmium, lead and mercury from polluted waters by the water hyacinth *Eichhornia crassipes*', *Environ. Pollut.* **A27**, 31–36.
9. Coles, D. G., Ragaini, R. C., Ondov, J. M., Fisher, G. L., Silberman, D. and Prentice, B. A.: 1979, 'Chemical studies of stack fly ash from a coal-fired power plant', *Environ. Sci. Technol.* **13**, 455–459.

Davison, R. L., Natusch, D. F. S., Wallace, J. R. and Evans, Jr, C. A.: 1974, 'Trace elements in fly ash: dependence of concentration on particle size', *Environ. Sci. Tech.* **8**, 1107–1113.

10. Farago, M. E. and Parsons, P. J.: 1985, 'The recovery of platinum metals by the water hyacinth', *Environ. Technol. Letters* **6**, 165–174.
11. Farago, M. E., Mehra, A. and Banerjee, D. K.: 1989, 'A preliminary investigation of pollution in the River Yamuna, Delhi, India: metal concentrations in river bank soils and plants', *Environ. Geochem. Health* **11**, 149–156.
12. Fulekar, M. H.: 1983, 'Release and behaviour of selected trace elements in soil-water environment caused by coal-fired power plants fly ash disposal', PhD Thesis, Jawaharlal Nehru University, New Delhi, India.

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

13. Fulekar, M. H. and Dave, J. M.: 1986, 'Disposal of flyash - An environmental problem', *Intern. J. Environ. Studies* **26**, 191–215.

14. Fulekar, M. H. and Dave, J. M.: 1990, 'Environmental impact assessment of fly ash from coal-fired power plants', *Encology* **4**, 25–34.

15. Fulekar, M. H., Naik, D. S. and Dave, J. M.: 1983, 'Heavy metals in Indian coals and corresponding fly-ash and their relationship with particulate size', *Intern. J. Environ. Studies* **9**, 139–144.

16. Haider, Z. S., Malik, K.M. A., Rahman, M.M. and Ali, M. A.: 1984, 'Pollution Control by the Water Hyacinth', in Thyagarajan, G. (ed.), *Proc. Internat. Conf. on the Water Hyacinth*, 7–11 February, 1983, UNEP, Nairobi, pp. 627–634.

17. Hardy, J. K. and Raber, N. B.: 1985, 'Zinc uptake by the water hyacinth: effects of solution factors', *Chemosphere* **14**, 1155–1166.

18. HSE: 1991, 'Guidance for classification of contaminated soils', HMSO, London.

19. Jamil, K.: 1990, 'Environmental Biology ofWater Hyacinth', ASF-Science Series, Vidyanagar, India.

20. Kaakinen, J. W., Jorden, R. M., Lawsani, M. H. and West, R. E.: 1975, 'Trace element behaviour in coal-fired power plant', *Environ. Sci. Techn.* **9**, 862–869.

21. Kabata-Pendias, A. and Pendias, H.: 1984, *Trace Elements in Soils and Plants*, CRC Press, Florida.

22. Khanna, P. R.: 1995, Addl. Chief Engineer, Rajghat Power House, New Delhi. Personal communication.

23. Klein, D. H., Andren, A. W., Carter, J. A., Emery, J. F., Feldman, C., Fulkerson, W., Lyon, W. S., Ogle, J. C., Talmy, Y., Van Hook, R. I. and Bolton, N.: 1975, 'Pathways of thirty-seven trace elements through coal-fired power plant', *Environ. Sci. Tech.* **9**, 973–979.

24. Klusek, C. S., Miller, K. M. and Heit, M. 1983, 'Trace element and radionuclide mass balances at a coal-fired electric generating station', *Environment International* **9**, 139–144.

25. Minocha, Y. P.: 1995, Superintending Engineer, Indraprastha Power Station, New Delhi. Personal communication.

26. Misra, U. C., Lalit, B. Y. and Ramachandran, T. V.: 1980, 'Radioactivity release to the environment by thermal power stations using coal as a fuel', *Sci. Total Environ.* **14**, 77–88.