# Study of Dry Coal Beneficiation in an Air Pulsated Stratifier

**Abhishek Kumar**
CSIR-National Metallurgical laboratory
Jamshedpur, India
abhishekkr@nmlindia.org

**Ganesh Chalavadi**
CSIR-National Metallurgical laboratory
Jamshedpur, India
gc@nmlindia.org

**Kalicharan Hembrom**
CSIR-National Metallurgical laboratory
Jamshedpur, India
khembrom@nmlindia.org

**Snehashish Tripathy**
CSIR-National Metallurgical laboratory
Jamshedpur, India
snehashish@nmlindia.org

## ABSTRACT

Coal keeps on doing a noteworthy job in the economic development of a country, particularly in metallurgical industries and power generation sectors. Coal is currently beneficiated predominantly in wet condition. The conventional methods for processing of coarse coal like heavy media bath, jigging etc. utilizes water. In the near future, coal resource and water resource is going to have a reverse distribution thus posing several hurdles to wet beneficiation technologies in coal cleaning. Thus, it is exigent to develop efficient dry beneficiation technology for coal. This paper presents a summarized assessment of performance of an Air Pulsated Stratifier with particular reference to Indian Coal. The study was carried out on coal samples having ash in the range of 30-33%. Response parameters considered for this study were ash reduction and yield of clean coal. Results are found to be encouraging as the experimental trials resulted in absolute reduction of Ash percentage in the range of 7-9% in single stage.

**KEYWORDS:** coal, heavy media bath, jigging, coal cleaning, dry beneficiation, air pulsated stratifier, ash reduction, yield

## 1. INTRODUCTION

Coal is an organic sedimentary rock, a natural fossil fuel formed over millions of years from the remains of decaying trees and vegetation [Rao & Gouricharan 2016]. Water is the richest asset on earth. India is among one of those countries with vast coal reserves where water is in scarcity. Water Resources Information System of India revealed that in the year 2010, 1588 $m^3$ of fresh water is available per capita per year. However, it has been projected that per capita surface water availability is likely to be reduced to 1401 $m^3$ and 1191 $m^3$ by the end of year 2025 and 2050 respectively [Web 1]. Due to rapid rise in population and growing economy of the country, there will be a continuous increase in demand for water, and it will become scarce in coming decades [Web 1]. Presently, most of the coal preparation plants are based on wet beneficiation techniques that records huge volume of water consumption. So, there is an alternative to wet

wet beneficiation [Lockhart, 1984]. Dry beneficiation has gained significant attention in the recent years because of dearth of fresh water and economical benefit over wet beneficiation as it circumvents the treatment and storage of wastewater [Honaker et. al. 2008, Sahu et. al. 2009]. For treatment of 50 X 6 mm coal feed FGX separator is used with limitation of -6mm maintaining in the range of 10-20% in order to ensure a fluidized bed [Honaker & Luttrell, 2007], for 3 X 1 mm coal particles AKAFLOW is being explored and for fine coal i.e. -1 mm coal particle Airtable is being used [Chalavadi et. al. 2016]. However, the treatment of coal fraction in the size range -6mm to 3mm is a bit less explored. In order to explore the dry coal beneficiation in this size range, authors have fabricated in house air pulsated stratifier unit and this paper discus about it in detail.

## 2. EXPERIMENTAL

Equipment Details:

For processing of coal samples of size range -6 mm to 3mm, Air Pulsated Stratifier (APS) is designed and fabricated in-house. APS comprises of following components a) Blower for air supply, b) a rotary valve for pulsating airflow, c) a stratifying chamber with provision of removing products layer wise and d) a perforated sheet of 3mm opening placed at the bottom of the stratification chamber through which air is distributed uniformly in to the chamber. This equipment works on batch scale (100 kg). Particle separation results with the help of pulsating airflow in order to produce the stratification. Since minimum fluidization velocity is a function of density and size, the particles will be distributed layer wise i.e. denser material will be at the bottom and lighter material will be at the top. Forces acting on a particle in APS are drag force, gravity force and buoyancy. The separation process generated three product streams i.e. clean coal product, middling and reject stream.
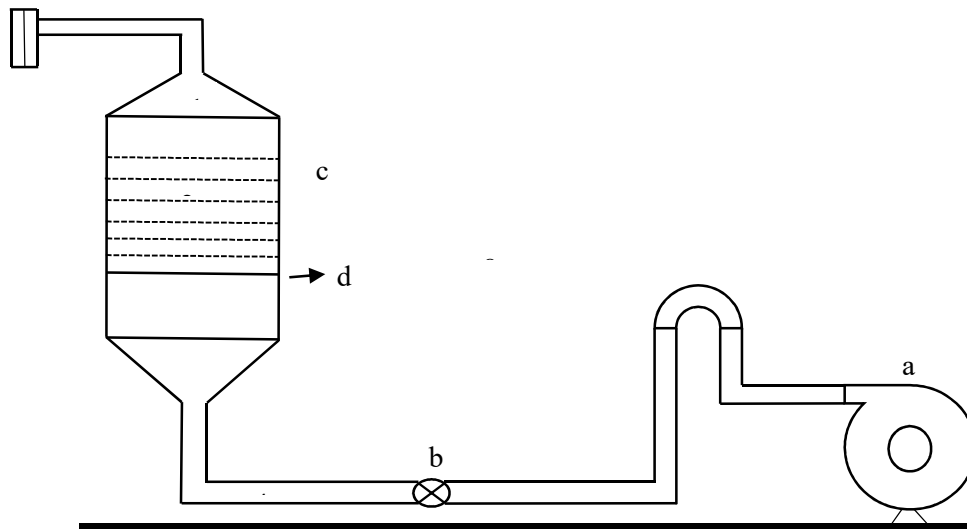


Figure 1: Schematic diagram of Air Pulsated Stratifier
a) Blower b) rotary valve c) a stratifying chamber and d) perforated sheet

Feed Characterization:

Coal feed sample has been subjected to Bomb calorimeter for estimation of Gross Calorific Value (GCV), which yields a GCV of 4090.3 kcal/kg. Further Proximate Analysis of the feed sample was done to estimate Moisture, Volatile Matter, Ash and Fixed Carbon and results are tabulated below in Table 1:

Table 1 Proximate analysis of feed sample:

| Moisture% | V.M.% | Ash% | FC% |
|-----------|-------|-------|-------|
| 7.56 | 25.88 | 31.02 | 35.54 |

The representative feed sample was subjected to sink-float tests by using the liquids with relative density in the range of 1.30 -2.00 prepared with the help of Bromoform and Benzene. Washability data is shown graphically in Figure 2.
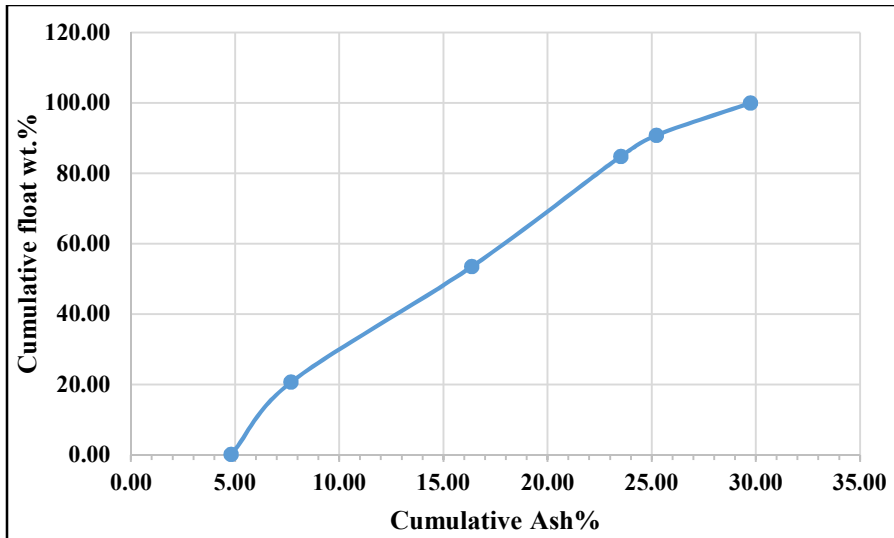
Figure 2: Washability curve of coal feed sample

Coal feed sample was analyzed with the help of Electron Probe Micro-Analyzer (EPMA). EPMA results were presented pictorially and graphically in Figure 3.
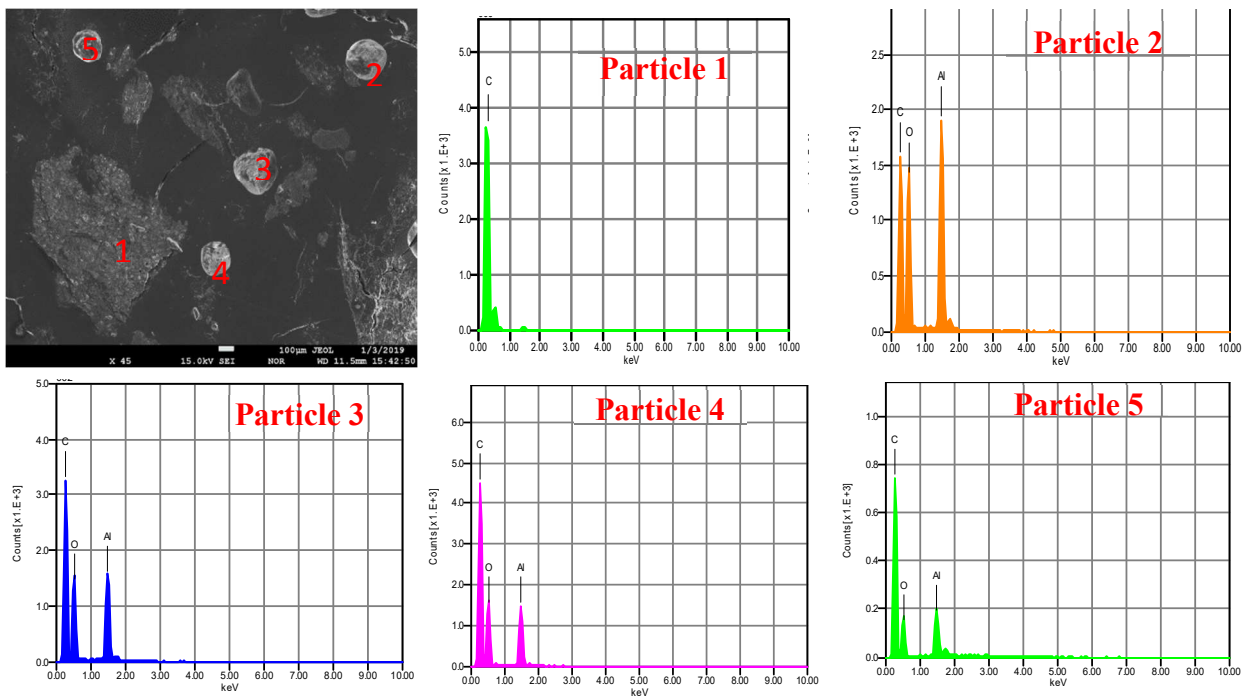


Figure 4: EPMA analysis results of coal feed sample

From EPMA results it is observed that particle 1 is showing peaks of coal particles and particle 2,3,4 & 5 is showing the presence of aluminosilicates.

Campaign Description:

Coal samples were prepared for processing in Air Pulsated Stratifier in the size range of -6 mm to 3 mm fractions. Samples were prepared by crushing them in a Jaw Crusher followed by a roll crusher. Two stage crushing was done in a Jaw crusher to bring down the size to around 13 mm. Further reduction was carried

out in roll crusher in closed circuit in order to minimize the generation of fines. After screening, the required size class of -6mm to 3 mm was obtained for carrying out campaign in Air Pulsated Stratifier. Effect of operating variables i.e. Blower frequency (BF) and Pulsation frequency (PF) were studied in terms clean coal grade and recovery. Optimum test performances and conditions were identified by varying the operating parameters systematically. After each campaigns each product streams were collected and weighed and representative samples are withdrawn for ash analysis.

## 3. RESULTS & DISCUSSION

The values of two critical operating parameters (Blower frequency & Pulsation frequency) were varied over 6 test campaigns. Campaign results are tabulated in Table 2 below:

Table 2 Results of the campaign with varying parameters

| Operating Parameters | | Streams | Wt.% | Ash% |
|---|---|---|---|---|
| BF = 40 Hz | PF = 60 Hz | Clean coal | 50.04 | 26.93 |
| | | Middling | 30.22 | 28.44 |
| | | Reject | 19.73 | 41.48 |
| BF = 40 Hz | PF = 50 Hz | Clean coal | 55.88 | 29.10 |
| | | Middling | 34.36 | 32.04 |
| | | Reject | 9.76 | 56.60 |
| BF = 40 Hz | PF = 40 Hz | Clean coal | 54.59 | 22.92 |
| | | Middling | 35.51 | 34.43 |
| | | Reject | 9.90 | 56.97 |
| BF = 50 Hz | PF = 40 Hz | Clean coal | 50.56 | 22.91 |
| | | Middling | 39.55 | 37.29 |
| | | Reject | 9.89 | 57.04 |
| BF = 50 Hz | PF = 50 Hz | Clean coal | 52.81 | 26.22 |
| | | Middling | 35.75 | 35.76 |
| | | Reject | 11.44 | 56.56 |
| BF = 50 Hz | PF = 60 Hz | Clean coal | 53.26 | 24.10 |
| | | Middling | 36.88 | 36.61 |
| | | Reject | 9.87 | 56.20 |

From the results tabulated above it can be inferred that, Pulsation frequency (PF) is playing important role in separation as compared to Blower frequency (BF). At higher levels of PF ash content is on the higher side corresponding to each level of BF. Best results of clean coal yield of 54.5% with 22.9% ash obtained at BF = 40 Hz and PF = 40 Hz.

Product characterization:

Clean coal product obtained at best operating conditions were analyzed with the help of EPMA. Results are presented in the figure 5 pictorially and graphically.
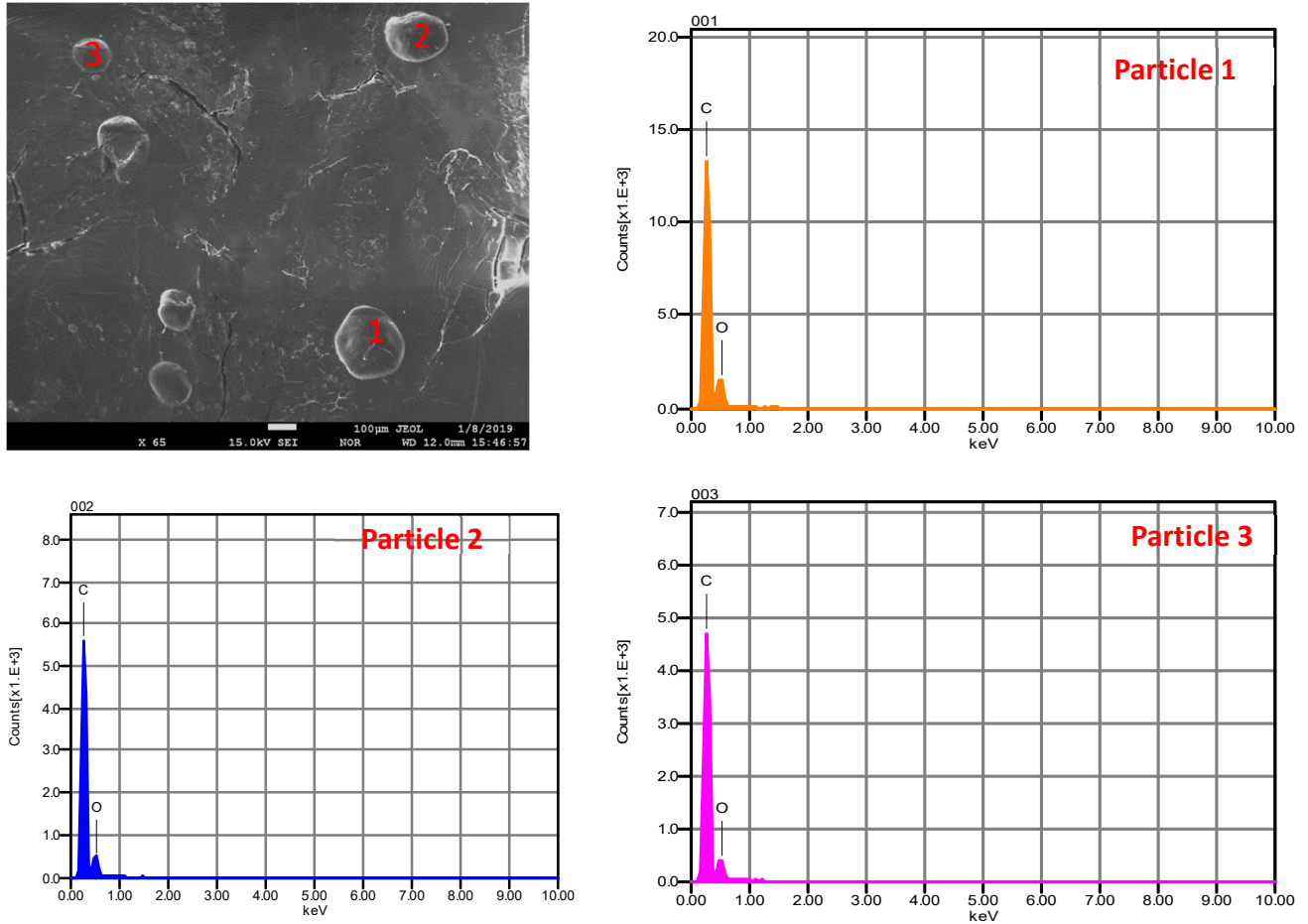


Figure 5: EPMA analysis of clean coal products.

## 4. CONCLUSION

The observation from the campaign reflects ability of Air Pulsated stratifier to efficiently reduce down the ash content. The yield was found to be around 54% at 22.9% ash, reducing the ash of coal feed sample by 8 units in single stage processing.

## 5. REFERENCES

1. D.V. Subba Rao & T. Gouricharan Coal Processing and Utilization, 2016, CRC press, ISBN no. 9781138029590-CAT # K29610.
2. N. C. Lockhart, Dry Beneficiation of Coal, *Powder Technology*, Vol. 40, Nos. 1–3, pp. 17–42 (1984).
3. Honaker, R. Q., M. Saracoglu, E. Thompson, R. Bratton, G. H. Luttrell, and V. Richardson. 2008. Upgrading coal using a pneumatic density based separator. International Journal of Coal Preparation and Utilization 28: 51–67.
4. A.K. Sahu, S.K. Biswal, A. Parida, Development of air dense medium fluidized bed technology for dry beneficiation of coal—a review, Int. J. Coal Prep. Util. 29 (2009) 216–241.
5. R.Q. Honaker, G.H. Lutrell. Final Technical Report "Development of an advanced deshaling technology to Improve the energy efficiency of coal handling, processing, and utilization operations" 2007.
6. Chalavadi, G., Singh, R. K., and Das, A., 2016, "Processing of coal fines using air fluidization in an air table." International Journal of Mineral Processing, 149. pp. 9–17.

Referencing Websites
1. www.india-wris.nrsc.gov.in/wrpinfo/index.php?title=India%27s_Water_Wealth

## 6. ACKNOWLEDGEMENTS