ISSN 2250-3153

Distribution of Silica in Different Density Fractions of Kusmunda Coals, Korba Coal Field

Manjula Sharaff[a], Sharad K. Vajpai[a], Kiran Vajpai[b]

[a] Chemistry Department, CMDubey Postgraduate College, Bilaspur- 495001
[b] Chemistry Department, Govt. Bilasa Girl's P.G. College, Bilaspur- 495001
E-mail: manjulasharaff@yahoo.com

Abstract - The huge amount of coal ash generated in our power plants can serve as important source for extraction of important ash constituents. Kusmunda area in Korba Coal field is an important source for power coals and therefore a bulk coal sample from the area has been studied in details as a test case for distribution of mineral matter in coal ash in different possible beneficiated and constituted dispatch material to power plants taking silica as a major and marker ash constituent. While, silica as percent of ash from samples under study remains within close limits, its retention in higher density is found much higher than in corresponding lower density.

Index Terms- Ash constituents, Silica, Density fraction

I. Introduction

Our main concern in utilization of coal for power industries has mostly been directed towards extraction of its fuel value while ash, the by-product of combustion of coal in our giant boilers, has so far been treated as hazardous waste of power industry despite its enormous mineral value for strategic and general industries. Almost the entire inorganic family of elements of periodic table is found to be present in the coal ash; some of these elements are present in major proportions while some in minor to trace levels in different combination states in coal ash. These constitute the inorganic value of coal ash and considering the enormous amount of ash production in power industry, coal ash can be considered as a mega potential source for these elements.

In view of the fact that silica constitutes nearly 60 per cent of the bulk of ash and at say 40 per cent ash in coal level, it represents 24 parts by weight of coal put in boiler, the present studies have been confined to the distribution of silica, as we try to fractionate a bulk coal sample from Kusmunda area, Korba Coal field, in the state of Chhattisgarh, into different size and density fractions, a normal physical method for obtaining suitable quality coals for a particular industry.

II. EXPERIMENTAL PARTICULARS

A bulk coal sample has been drawn from the Kusmunda area, Korba Coal field and brought to the Central Institute of Mining and Fuel Research CIMFR laboratory, Bilaspur for processing and preparation of desired laboratory samples for characterization and detailed studies.

The bulk sample after weighing was passed through 100 mm screen crushing any plus 100 mm material manually and without using much violence. The bulk now is put on screens of 25mm, 13mm, 6mm, 3mm, and 0.5mm apertures. Thus different size fractions 100-25mm, 25-13mm, 13-6mm, 6-3mm, 3-0.5mm and -0.5mm were obtained. Individual size fractions were weighed and aliquot representative samples were separated by thorough mixing and coning and quartering. These aliquots of individual size fractions were weighed and used for density separation using float and sink test. For this purpose, liquids of different densities of 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, and 1.9 g/cc. were prepared by mixing benzene, carbon tetrachloride and bromoform in desired proportions.

During actual of gradually experiment, solutions increasing densities were taken in different containers in a row and a particular coal sample, say 100-25 mm material, was put in first container containing 1.3 density liquid. The material floating in the liquid was carefully separated and labeled as sample of < 1.3 density. The sink material was taken out and dried in air and then put in solution of next higher density, say 1.4. The float of this density was labeled as 1.3-1.4 density material. The sink was again put in next higher density liquids i.e. 1.5. The process was continued till we separated the floats and sinks in 1.9 density solution. The floats and sinks of different densities thus separated are dried in air and weighed individually. The process was repeated for aliquots of different size fractions separated from the bulk coal sample.

Floats and sinks of all size fractions were weighed individually and crushed to prepare 72 mesh size coal samples as per BIS: 436, (Part 1/ Section 1) - 1964 and IS: 436, (Part 2/ Section 2) - 1976.

A bulk coal sample representing properties and qualities of original bulk sample collected from the mine was also prepared by mixing powdered (72 mesh) individual size fractions in weight proportions (as obtained on screening of the bulk coal sample).

The 72 mesh ground samples of individual size fractions, their respective floats and sinks and the constituted bulk sample formed the material for characterization and ash analysis in the laboratory.

About 15-20 g of individual sample(s) is taken and uniformly distributed in a silica dish. The dish with the sample is now introduced in a ventilated muffle furnace at room temperature and the temperature of the furnace is gradually raised to 850^0C and maintained them till complete combustion. The ash is cooled to room temperature and finely ground using an agate mortar. Thus finely ground and uniformly mixed ash is again heated for an hour or so at 815^oC in muffle furnace to burn any unburnt carbon residue in the ash.
Ash for individual floats and sinks of different densities of 100-25mm, 25-13mm, 13-6mm, 6-3mm, 3-0.5mm size and the bulk coal samples have been obtained as above and subjected to detailed ash analysis following BIS: 1355-1984.
The distribution of Silica as a marker and major constituent of coal ash in different density fractions of individual size fractions has been followed as below. Though the major proportion of silica found in coal ash, is never present in coal as such (free silica), the results have been projected in terms of silica on coal for ease of appreciation.

III. RESULTS AND DISCUSSION

The results of distribution of silica in different size fractions have been summarized in Table-1.

Table: 1 Distribution of Silica (SiO_2) in different size fractions

Size Fraction(in mm)	Wt. (in Tonnes)	Silica(in Tonnes)	Silica as % of mass of size consist	Silica as Part of Total Silica in bulk coal
100-25	54.9	14.24	25.93	61.48%
25-13	8.8	1.97	22.43	8.51%
13-6	13.1	2.69	20.56	11.61%
6-3	6.2	1.03	16.57	4.45%
3-0.5	10.1	1.66	16.46	7.16%
-0.5	6.9	1.57	22.72	6.78%
Bulk Coal	100.0	23.16	23.16	100%

From Table 1 it has seen that 100 tonnes of the bulk coal contains 23.16 tonnes silica in its ash. Of this 14.24 tonnes silica is present in 100-25mm, 1.97 tonnes silica in 25-13mm, 2.69 tonnes in 13-6mm, 1.66 tonnes in 3-0.5mm and 1.57 tonnes silica is present in -0.5mm size material.
The results of distribution of silica in different density fractions separated from the 100-25 mm size fraction material obtained from the bulk coal sample have been summarized in the table below.

Table- (2a) SiO_2 in 100-25mm Screen Fraction

Density range	Wt %	Dry ash%	SiO_2%	SiO_2 as % of dry coal	Fraction of SiO_2 in 100-25mm coal	Fraction of SiO_2 in bulk coal	Fraction % of total SiO_2 in bulk coal
<1.3	4.4	9.1	61.16	5.56	0.24	0.132	0.6
1.3-1.4	20.7	17.8	61.60	11.0	2.27	1.246	5.4
1.4-1.5	25.1	28.6	63.52	18.08	4.56	2.503	10.8
1.5-1.6	15.6	39	64.44	25.13	3.92	2.152	9.3
1.6-1.7	8.1	46.7	64.27	30.01	2.43	1.334	5.8
1.7-1.8	6.8	53.8	65.00	35.00	2.38	1.307	5.6
1.8-1.9	5.9	60.8	65.22	39.65	2.34	1.285	5.5
>1.9	13.4	89.8	64.83	58.20	7.80	4.282	18.5
Overall	100	40.4	64.20	25.93	25.93	14.24	61.5

The 100-25 mm size fraction representing 54.9 per cent mass of the bulk Kusmunda coal sample is found to have 14.24 tonnes of SiO_2 in its coal ash; this is 61.5 % of the total 23.16 tonnes of SiO_2 in coal ash from the original bulk coal sample. This is further distributed in different densimetric fractions between <1.3 density and >1.9 density. In <1.3 density material, SiO_2 concentration is found to be the lowest, a mere 0.13 tonne and increases up to 2.5 tonnes in 1.4-1.5 density material. Silica is practically found constant at around 1.3 tonnes in fractions between 1.6-1.9 densities. The >1.9 density material has retained 4.28 tonnes of silica in its ash. Thus 1.4-1.6 density material retains 20.1% silica, > 1.9 density material retains 18.5 % while 28.2 % of silica of original bulk coal sample is found distributed in <1.3, 1.3-1.4, and 1.6-1.9 density fractions

The distribution of silica in 25-13 mm size fraction has been presented in table below.

Table- (2b) SiO_2 in 25-13mm screen fraction

Density range	Wt %	Dry ash%	SiO_2%	SiO_2 as % of dry coal	Fraction of SiO_2 in 25-13mm coal	Fraction of SiO_2 in bulk coal	Fraction % of total SiO_2 in bulk coal
<1.3	17.6	8.8	60.24	5.30	0.93	0.082	0.4
1.3-1.4	21.6	19.1	60.77	11.61	2.51	0.221	1.0
1.4-1.5	17.6	28.4	62.28	17.69	3.11	0.274	1.2
1.5-1.6	13.9	38.2	63.13	24.12	3.35	0.295	1.3
1.6-1.7	6.8	47.6	64.42	30.66	2.09	0.184	0.8
1.7-1.8	4.9	54	65.32	35.27	1.73	0.152	0.7
1.8-1.9	3.9	59	65.56	38.68	1.51	0.133	0.6
>1.9	13.7	81.2	64.60	52.52	7.20	0.634	2.7
Overall	100	35.3	63.54	22.43	22.43	1.98	8.5

The 25-13mm size fraction represents 8.8 per cent of the mass of the bulk sample and is found to contain 1.98 tonnes of total 23.16 tonnes of SiO_2 contributing 8.5% to the total SiO_2 of the original bulk coal sample. On density separation, highest proportion 0.634 tonne is found retained in > 1.9 density material while the < 1.3 density fraction has a mere 0.082 tonnes of silica in its ash. The 1.3-1.6 density material is found to retain 0.79 tonnes of silica and the remaining 0.469 tonnes of silica are found distributed in 1.6-1.9 density material. In terms of total silica in the bulk coal sample, 3.5 % of it is found in 1.3-1.6 density fraction,0.21 % in 1.6-1.9 density fractions, 0.4 % in <1.3 density material and the remaining 2.7 % is found retained in the >1.9 density material

Silica distribution in different density fractions of 13-6 mm size fraction of the bulk Kusmunda coal sample has been presented in the table below.

Table- (2c) SiO_2 in 13-6mm screen fraction

Density range	Wt %	Dry ash%	SiO_2%	SiO_2 as % of dry coal	Fraction of SiO_2 in 13-6 mm coal	Fraction of SiO_2 in bulk coal	Fraction % of total SiO_2 in bulk coal
<1.3	24.3	6.5	58.66	3.81	0.93	0.122	0.5
1.3-1.4	21.3	16.7	60.38	10.09	2.15	0.282	1.2
1.4-1.5	13	26.9	62.97	16.94	2.20	0.288	1.2
1.5-1.6	13.3	36.5	63.30	23.10	3.07	0.402	1.7
1.6-1.7	6.6	45.9	64.17	29.45	1.94	0.254	1.1
1.7-1.8	2.6	51.2	63.86	32.70	0.85	0.111	0.5
1.8-1.9	3.6	56.3	65.97	37.19	1.34	0.176	0.8
>1.9	15.3	81.8	64.57	52.81	8.08	1.058	4.6
Overall	100	32.4	63.47	20.56	20.56	2.69	11.6

The 13-6mm size fraction representing 13.1 per cent of the bulk Kusmunda coal sample contributes 2.69 tonnes or 11.6% silica of total silica of the bulk coal. Silica concentration is found maximum in >1.9 density material amounting to 1.058 tonnes constituting 4.6 % of total silica of the bulk coal sample. The 1.5-1.6 density fraction retains 0.40 tonne representing 1.7% of total silica. The material up to 1.5 densities retains 0.69 tonnes of silica forming 2.9 % of silica of original coal. The remaining 0.94 tonnes is found distributed in 1.6-1.9 density material representing 2.4 % of total silica of the bulk coal sample.

Silica distribution in 6-3 mm size fraction has been given in table below.

Table- (2d) SiO_2 in 6-3mm screen fraction

Density range	Wt %	Dry ash%	SiO_2%	SiO_2 as % of dry coal	Fraction of SiO_2 in 6-3mm coal	Fraction of SiO_2 in bulk coal	Fraction % of total SiO_2 in bulk coal
<1.3	33.1	3.7	58.5	2.16	0.72	0.045	0.2
1.3-1.4	19.2	12.6	58.9	7.42	1.42	0.088	0.4
1.4-1.5	13.8	25	61.04	15.26	2.11	0.131	0.6
1.5-1.6	8.8	35.2	62.85	22.12	1.95	0.121	0.5
1.6-1.7	4.9	42.8	63.42	27.14	1.33	0.082	0.4
1.7-1.8	2.4	46.8	65.02	30.43	0.73	0.045	0.2
1.8-1.9	2.8	51.4	64.45	33.13	0.93	0.058	0.2

>1.9	15.0	77	63.67	49.03	7.35	0.456	2.0
Overall	100	26.4	62.80	16.54	16.54	1.03	4.4

The 6-3mm size fraction from Kusmunda coals representing 6.2 per cent of the bulk, contributes 4.4% or 1.03 tonnes of 23.16 tonnes of the total silica in bulk coal. Silica is found more concentrated in 1.4-1.6 density fraction representing 0.252 tonnes or 1.1 % of total silica of bulk sample. Silica in density fraction up to 1.4 densities is 0.6 % and between 1.6-1.9, it would be 0.185 tonnes or 0.8 % of total silica in bulk coal sample. The >1.9 density material retains 0.456 tonnes or 2 per cent of total silica present in the bulk coal.

Silica distribution in 3-0.5 mm finer coals is presented below.

Table- (2e) SiO_2 in 3-0.5mm screen fraction

Density range	**Wt %**	**Dry ash%**	**SiO_2%**	**SiO_2 as % of dry coal**	**Fraction of SiO_2 in 3-0.5mm coal**	**Fraction of SiO_2 in bulk coal**	**Fraction % of total SiO_2 in bulk coal**
<1.3	2.2	3	56.18	1.69	0.37	0.037	0.2
1.3-1.4	35.8	9.5	58.89	5.59	2.00	0.202	0.9
1.4-1.5	9.9	23.9	60.12	14.37	1.42	0.143	0.6
1.5-1.6	6.8	33.9	62.11	21.06	1.43	0.144	0.6
1.6-1.7	3.3	39.4	62.56	24.65	0.81	0.082	0.4
1.7-1.8	2.5	44.8	62.99	28.22	0.71	0.072	0.3
1.8-1.9	2.1	48.2	63.44	30.58	0.64	0.065	0.3
>1.9	17.4	81.8	64.12	52.41	9.12	0.921	4.0
Overall	100	26.3	62.57	16.50	16.50	1.67	7.2

The 3-0.5mm size material forming 10.1 per cent of the bulk coal sample from Kusmunda area, contributes 1.67 tonnes or 7.3% of total SiO_2 present in bulk coal. The >1.9 density material analyses 0.921 tonnes of silica in its ash representing 4% of total silica of bulk coal. The <1.3 density fraction retains 0.037 tonnes , a mere 0.2% of total silica of bulk sample while 1.3-1.6 density fraction is found to retain 2.1% of total silica. Density fractions between 1.6-1.9 densities retain 0.219 tonnes of silica forming 1 % of total silica in bulk coal.
It is thus seen that in coal sample from Kusmunda area, major proportion of total silica is retained in 100-25 mm fraction. The contribution of other size fractions in retention of silica is in the order 13-6mm fraction > 25-13 mm fraction > 3-0.5 mm fraction > -0.5mm material > 6-3mm size fraction. Again in different size fractions, the maximum silica is found to be retained in material > 1.9 density.

IV. BENEFICIATION OF DIFFERENT SIZE FRACTIONS AT 1.6 DENSITY

The coal beneficiation studies are usually aimed at obtaining a suitable density for separation of it two or more products of the exercise to sustain criterion of ash and gainful utilization of coal resources. Based on our studies of separation of individual size fractions of Korba coals in liquids of densities between 1.3 and 1.9, we have selected 1.6 and 1.8 densities of separation of individual size fractions for presentation of yield and quality of separated floats and sinks and distribution of silica in them.
The results of the exercise have been compiled as below**:**

Table: (3a) Distribution of Silica in different size fractions at 1.6 density liquid

Size fractions	**Floats at 1.6 density**			**Sinks at 1.6 density**		
	Yield	**Ash%**	**Floats(Silica)**	**Yield**	**Ash%**	**Sinks(Silica)**
100-25 mm	36.12	26.40	6.03	18.78	63.40	8.21
25- 13mm	6.20	22.61	0.86	2.6	65.70	1.09
13-6mm	9.42	18.76	1.09	3.68	64.30	1.60
6-3mm	4.64	13.60	0.38	1.56	62.10	0.65
3-0.5mm	7.54	11.70	0.52	2.56	65.00	1.14

When individual size fractions obtained from the bulk coal sample from Kusmunda area, Korba CF are put in a liquid of 1.6 density, the yield of floats would be 36.12, 6.20, 9.42, 4.64 and 4.14 tonnes with 26.40, 22.61, 18.76,13.6 and 11.7 per cent ash for 100-25 mm, 25-13 mm, 13-6 mm, 6-3 mm and 3-0.5 mm size fractions respectively. The corresponding sinks would be 18.78, 2.6, 3.68, 1.56 and 2.56 tonnes with 63.4, 65.7, 64.3, 62.1 and 65.0 per cent ash. This would also leave an unwashed 6.9 tonnes of x 0.5 mm fines containing 1.57 tonnes of silica in its ash.

A 100 tonne bulk Kusmunda coal sample with 23.16 tonnes of silica in its ash retains. Of this 14.24 tonnes of silica is present in ash of 100-25mm size fraction. After beneficiation treatment at 1.6 density 6.03 tonnes of silica is retained in floats while 8.21 tonnes of silica goes with the sinks.

The 25-13mm and 13-6mm size fractions, respectively retain 0.86 tonnes and 1.09 tonnes of silica in the floats while 1.09 and 1.60 tonnes of silica goes with the sinks .In 6-3mm and 3-0.5mm sizes, 0.38 and 0.52 tonnes of silica remains in the floats while 0.65 and 1.14 tonnes goes along with the sinks of these size consists respectively.

Thus sinks at 1.6 density still have sufficient fuel value and have potential for their utilization in power generation with or without requiring specialized high ash combustors, the ash generated in these boilers will be found more concentrated in terms of silica and so also for other ash constituents.

In quest of extracting higher quantities of power coals while leaving behind as little quantity as possible of true rejects devoid of practically any meaningful caloric content.

V. BENEFICIATION OF DIFFERENT SIZE FRACTIONS AT 1.8 DENSITY

The floats and sinks at 1.8 density level can be investigated in terms of yield of floats and distribution of silica. The results of the exercise have been as per below.

Individual size fractions separated from the bulk coal sample were put in a solution of 1.8 density prepared by mixing appropriate quantities of carbon tetra chloride and bromoform liquids.

The separated floats and sinks were air dried and weighed and laboratory samples were prepared for characterization and ash analysis.

The results of the exercise have been compiled on the next page.

Table: (3b) Distribution of Silica in different size fractions at 1.8 density liquid

Size Fraction	**At 1.8 density**					
	Yield	**Ash%**	**Floats(Silica)**	**Yield**	**Ash%**	**Sinks(Silica)**
100-25mm	44.3	30.70	8.67	10.6	73.80	5.57
25-13mm	7.25	26.55	1.21	1.55	76.00	0.76
13-6mm	10.62	22.00	1.46	2.48	72.50	1.23
6-3mm	5.10	16.31	0.51	1.10	69.40	0.52
3-0.5mm	8.13	13.86	0.67	1.97	71.90	0.99

It is pertinent to note that ash in sinks of all the size fractions at 1.8 density analyse pretty high ash and can be considered as true dirts. However, they still have some fuel value which can be extracted in fluidized bed combustors for power generation.

The yield of floats for 100-25 mm size fraction would be 44.3 tonnes with 30.7 per cent ash. For 25-13 mm material, the yield of floats at 1.80 sp gr would be 7.25 tonnes with 26.55per cent ash. The floats of 13-6 mm fraction would be 10.62 tonnes with 22.0 per cent ash while the floats for 6-3 mm and 3-0.5 mm material are found to be 5.10 and 8.13 tonnes with 16.31 and 13.86 per cent ash respectively. The yield of sinks would be 10.6 tonnes with 73.80 per cent ash for 100-25mm, 1.55 tonnes with 76.00 per cent ash for 25-13mm, 2.48 tonnes with 72.50 per cent ash for 13-6mm, 1.10 tonnes with 69.40 per cent ash for 6-3 mm and 1.97 tonnes with 71.90 per cent ash for 3-0.5mm size fractions leaving 6.9 tonnes of unwashed 0.5 mm fines.

The amount of silica retained in floats of these different size fractions is found to be 8.67 tonnes for 100-25 mm, 1.21 tonnes for 25-13 mm, 1.46 tonnes for 13-6 mm, 0.51 tonnes for 6-3 mm and 0.67 tonnes for 3-0.5 mm size consists. The unwashed x0.5 mm material retains 1.57 tonnes of silica.

Sinks for these size fractions at 1.80 density has been found to be 5.57, 0.76, 1.23, 0.52 and 0.99 tonnes respectively.

Thus if 93.10 tonnes of 100-0.5 mm material is put in a liquid of 1.8 sp.gravity, the yield of floats would be 75.40 tonnes retaining 12.52 tonnes of silica while the material sinking in the liquid would be 17.70 tonnes with 9.07 tonnes of silica.

VI. BENEFICIATION OF DIFFERENT CUMULATIVE SIZES AT 1.6 DENSITY

The coals excavated in a mine is generally fractioned in two or three broad size fractions suggested on the basis of detailed screen analysis data generated in a laboratory study. The exercise enables coal producers to optimize their coal supplies while suiting the requirements of the consumer industries. Therefore, ash generated in a particular plant and therefore, quantities of different ash constituents would depend upon the quality and quantity of combination fractions included or excluded from the coal supplies. Again coal beneficiation may be pursued for such constituted samples to improve their quality leaving one or more size fraction(s) untreated and mixed in the product for final dispatch.

Accordingly studies were made to ascertain the distribution of ash constituents in different possible combinations in coal supplies. The results of beneficiation of the possible combinations at 1.6 and 1.8 density of separation have been summarized below:

Table: (4a) Distribution of silica in different cumulative sizes at 1.6 density liquid

Size fractions	At 1.6 density					
	Yield	Ash%	Floats(Silica)	Yield	Ash%	Sinks(Silica)
+25mm	36.12	26.40	6.03	18.78	63.30	8.21
+13mm	42.32	25.90	6.89	21.38	63.60	9.32
+6mm	51.74	25.40	7.98	25.06	63.70	10.92
+3mm	56.38	24.30	8.36	26.62	63.60	11.57
+0.5mm	63.92	22.80	8.88	29.18	63.70	12.73

On density separation of broad size constituted samples at 1.6 sp. gravity, the yield of floats increases while the ash per cent decreases as we include more and more finer sizes .The yield of floats of +25mm has been found to be 36.12 tonnes with 26.40 per cent ash, For + 13 mm material the yield would be 42.32 tonnes with 25.90 per cent ash, for +6mm, the yield of floats would be 51.74 tonnes with 25.40 per cent ash while the yield of floats for +3 and +0.5 mm constituted samples would be 56.38 and 63.92 tonnes with 24.30 and 22.80 per cent ash respectively.

This also increases proportion of ash constituents in the floats and sinks on inclusion of more fine sizes in the constituted samples. Thus silica retained in the floats ash increases from 6.03 tonnes to 8.88 tonnes as we move from +25 mm material to +0.5 mm constituted sample. Silica for the sinks of these samples also follows the same trend as it increases from 8.21 tonnes to 12.71 tonnes on moving from +25 mm to +0.5 mm constituted sample. The corresponding finer size material (-25mm,-13 mm, -6 mm, -3 mm and -0.5 mm) accordingly would have lesser retention of these constituents in their ash.

VII. BENEFICIATION OF DIFFERENT CUMULATIVE SIZES AT 1.8 DENSITY

On repeating the exercise of separation of floats and sinks from constituted samples at 1.8 density, the results of distribution of silica obtained have been compiled below.

Table: (4b) Distribution of silica in different cumulative sizes at 1.8 density liquid

Size fractions	At 1.8 density					
	Yield	Ash%	Floats(Silica)	Yield	Ash%	Sinks(Silica)
+25mm	44.30	30.70	8.67	10.60	73.80	5.57
+13mm	51.55	30.10	9.88	12.05	74.10	6.33
+6mm	62.17	28.70	12.12	14.63	73.80	6.78
+3mm	67.27	27.80	12.63	15.73	73.50	7.31
+0.5mm	75.40	26.30	13.30	17.70	73.30	8.29

The amount of floats and sinks separated from constituted broad size fractions of Kusmunda coal sample at 1.8 density increases from + 25 mm material to +0.5 mm coals. The ash per cent of floats decreases as we include more and more finer size material while the ash per cent of corresponding sinks are higher than floats but do not follow a regular order. The ash per cent of sinks of +13mm size is highest in 1.8 density and lowest in +0.5mm size. In floats, silica increases from 8.67 tonnes to 13.30 tonnes as we move from +25 mm floats to +0.5 mm floats. Similar trend is maintained in sinks too and the silica increases from 5.57 tonnes to 8.29 tonnes as we move from +25 mm sinks to +0.5 mm sinks.

The Indian coals, due to their drift origin have, been responsible for generation of extremely large quantities of ash in major power plants of the country. Since coal ash is known to contain a number of major and minor ash constituents of commercial significance the huge tonnage of ash generated in our plants can be treated as source material for these constituents. In the light of this the present studies were under taken on a bulk coal sample from Kusmunda mine, Korba Coalfield in Korba District of Chhattisgarh.

To evaluate the movement and distribution pattern of silica in different density fractions individual size fractions from the bulk coal sample were subjected to float and sink tests using organic liquid mixtures of different densities between 1.3 and 1.9. Aliquots of separated samples representing density fractions of individual size consists of the original bulk sample were characterized and studied for silica content in their ash.

It is seen that there is an increase in silica content as we move to higher density fractions. Thus the100-25mm size coal which has14.24 tonnes SiO_2 in its coal ash amounting to 61.5 per cent of the total 23.16 tonnes of SiO_2 in coal ash from the original bulk coal sample. In <1.3 density material, SiO_2 retained is 0.13 tonne and the amount increases up to 2.5 tonnes in 1.4-1.5 density material. It is practically found constant at around 1.3 tonnes in fractions between 1.6-1.9 densities. The >1.9 density material has 4.28 tonnes of silica in its ash. Thus 1.4-1.6 density material retains 20.1 per cent silica, > 1.9 material retains 18.5 per cent while 28.2 per cent of silica of original bulk coal sample is found distributed in <1.3, 1.3-1.4, and 1.6-1.9 density fractions.

The 25-13mm size fraction contains 1.98 tonnes of of SiO_2 constituting 8.5 per cent of total SiO_2 of the original bulk coal sample. On density separation, silica is found concentrating more in higher density fractions, It is 0.634 tonnes in >1.9 density material while <1.3 density fraction has a mere 0.082 tonnes of silica in its ash. Similarly the 1.3-1.6 density material is found to retain 0.79 tonnes of silica and the remaining 0.416 tonnes of silica are found distributed in 1.6-1.9 density material. In terms of total silica in the bulk coal sample, 3.5 per cent of it is found in 1.3-1.6 density fraction,0.21 per cent in 1.6-1.9 density fractions, 0.4 per cent in <1.3 density material and the remaining 2.7 per cent is found retained in the >1.9 density material

The 13-6mm size fraction of Kusmunda coals contributes 2.69 tonnes or 11.6 per cent silica of total silica in bulk coal. Silica concentration is found maximum in >1.9 density material amounting to 1.058 tonnes constituting 4.6 per cent of total silica of the bulk coal sample. The 1.5-1.6 density fraction retains 0.40 tonne which would be 1.7 per cent of total silica The material up to 1.5 density retains 0.69 tonnes of silica forming 2.9 per cent of silica of original coal. The remaining 0.54 tonnes is found distributed in 1.6-1.9 density material representing 2.4 per cent of total silica of the bulk coal sample.

The 6-3mm size fraction from Kusmunda coals contributes 4.4 per cent or 1.03 tonnes of 23.16 tonnes of the total silica in bulk coal. Silica is found more concentrated in 1.4-1.6 density fraction representing 0.252 tonnes or 1.1 per cent of total silica of bulk sample. Silica in density fraction up to 1.4 densities is 0.6 per cent and between 1.6-1.9, it would be 0.185 tonnes or 0.8 per cent of total silica in bulk coal sample. The >1.9 density material retains 0.456 tonnes or 2 per cent of total silica present in the bulk coal.

The 3-0.5mm size material from Kusmunda coals contributes 1.67 tonnes or 7.3 per cent of total SiO_2 present in bulk coal. Silica is found more concentrated in >1.9 density material, 0.921 tonnes, representing 4 per cent of total silica of bulk coal. The <1.3 density fraction retains 0.037 tonnes, a mere 0.2 per cent of total silica of bulk sample while 1.3-1.6 density fraction retains 2.1 per cent of total silica. Density fractions between 1.6-1.9 densities retain 0.219 tonnes of silica forming 1 per cent of total silica in bulk coal

Based on the results of separation of individual size fractions of Korba coals in liquids of densities between <1.3 and >1.9, 1.6 and 1.8 densities have been selected for separation of individual size fractions for presentation of yield and quality of separated floats and sinks and distribution of ash constituents in them.

When this sample is fractionated in different size fractions and put in a liquid of 1.6 density, the yield of floats would be 36.12 tonnes of 100-25 mm material, 6.2 tonnes of 25-13 mm fraction, 9.42 tonnes of 13-6 mm fraction, 4.64 tonnes of 6-3 mm material and 7.54 tonnes of 3-0.5 mm material, leaving 6.9 tonnes of unwashed 0.5 mm fines.

A 100 tonne bulk Kusmunda coal sample has 23.16 tonnes of silica in its ash. Out of this 14.24 tonnes of silica is present in ash of 100-25mm size fraction. After beneficiation treatment at 1.6 density 6.03 tonnes of silica is retained in floats while 8.21 tonnes of silica remains in sinks. In 25-13mm and 13-6mm size fractions, respectively 0.86 tonnes and 1.09 tonnes of silica is retained in the floats while 1.11 and 1.60 tonnes of silica goes with the sinks of these size fractions. In 6-3mm and 3-0.5mm sizes, 0.38 and 0.52 tonnes of silica is present in floats while 0.65 and 1.13 tonnes is retained in sinks of these size consists respectively.

When this sample is fractionated in different size fractions and put in a liquid of 1.8 density, the yield of floats would be 44.3 tonnes of 100-25 mm material, 7.59 tonnes of 25-13 mm fraction, 11.10 tonnes of 13-6 mm fraction, 5.27 tonnes of 6-3 mm material and 8.34 tonnes of 3-0.5 mm material, leaving 6.9 tonnes of unwashed 0.5 mm fines.

The floats of 100-25mm material at 1.80 density will have 8.67 tonnes of silica leaving 5.57 tonnes in the sinks. The floats of 25-13mm size consists will have 1.21 tonnes of silica while the sinks would carry 0.76 tonnes, the floats of 13-6mm, 6-3mm and 3-0.5mm material will have 1.46, 0.51 and 0.67 tonnes of silica in their ash respectively while corresponding sinks would carry 1.23, 0.52 and 0.98 tonnes of silica respectively.

Again coal beneficiation may be pursued for special constituted samples to improve their quality leaving one or more size fraction(s) untreated and mixed in the product for final dispatch. Accordingly studies were made to ascertain the distribution of silica in different possible combinations in coal supplies.

On density separation of broad size constituted samples at 1.6 and 1.8 sp. gravities, the yield of floats and sinks increases as we include more and more finer sizes. This also increases proportion of silica in the floats and sinks leaving the corresponding untreated finer size consists poorer in these constituents.

The amount of floats separated from Kusmunda coals from different constituted coal samples at 1.6 sp. gravity shows a continuous increase from 36.12 per cent of the size consist for +25 mm material to 63.92 per cent for +0.5 mm coals. Since finer coals have better separation of dirt and coaly matter, and hence the lighter coal particles get preferentially included in the floats, there is an increase in the yield of sinks from +25mm i.e. 18.78 per cent to 29.18 per cent for +0.5 mm constituted material.

Silica increases from 6.03 tonnes of the total silica in bulk coal sample in floats of + 25 mm sample to 8.88 tonnes in floats of + 0.5 mm material and in sinks increases from 8.21tonnes of total silica in bulk coal for + 25 mm material to 12.73 tonnes of total silica in +0.5 mm sinks at 1.6 sp. gravity.

The amount of floats separated from Kusmunda coals at1.8 density increases from 44.3 per cent of the + 25 mm material to 75.4 per cent of the +0.5 mm coals. The same trend is followed weights of sinks from 10.6 per cent for + 25 mm coals to 17.7 per cent for the sinks of +0.5mm.

Silica in floats as per cent of total silica in bulk coal increases from 8.67 tonnes for + 25 mm material to 13.30 tonnes for floats of +0.5 mm coals. Similar increase in concentrations of these constituents is found as we move from sinks of +25mm coals to sinks of +0.5 mm coals from 5.57 tonnes to 8.31 tonnes.

VIII. CONCLUSION

It is seen that there is an increase in silica content as we move to higher density fractions. The100-25mm size coal which has14.24 tonnes SiO_2 in its coal ash amounting to 61.5 per cent of the total 23.16 tonnes of SiO_2 in coal ash from the original bulk coal sample. When this sample is fractionated in different size fractions and put in a liquid of 1.6 density, the yield of floats would be 36.12 tonnes of 100-25 mm material with 6.03 tonnes silica leaving 8.21 tonnes in sinks. After getting fractionated in different size fractions and put in a liquid of 1.8 density, the yield of floats would be 44.3 tonnes of 100-25 mm material with 8.67 tonnes silica leaving 5.57 tonnes in the sinks. Thus for silica separation beneficiation of 100-25mm size fraction at 1.8 density can be suggested.

ACKNOWLEDGEMENT

We are thankful to Mr. B. L. Shah ex-OIC, CFRI (earlier CIMFR), Mr. A. K. Chattopadhyay, OIC and Dr. A. K. Sharma, Principal Scientist, Mr. S. K. Konar, Senior Technical Officer, CIMFR Bilaspur Unit for their valuable co-operations and suggestions for preparation of this paper.

REFERENCE

[1] Sarkar G.G, "An introduction to Coal Preparation Practice", Oxford and IBH Publishing Company Ltd 1986.
[2] BIS 436 (Part I, 1964):- Sampling of coal.
[3] S. C. Tsai, "Fundamentals of Coal Beneficiation and Utilization" Elsevier Scientific Publishing Company, Amsterdam- Oxford- New York, 1982.
[4] BIS 1350 (Part I), 1984:-Proximate analysis.
[5] Valkovic Vlado "Trace Elements in Coal Vol - II, CRC Press, 1983
[6] BIS 1355, 1984:- Methods of determination of the chemical composition of the ash of coal and coke.
[7] Unpublished Annual reports of Central Fuel research Institute, Bilaspur Unit.
[8] Bernard R. Cooper, William A. Ellingson, "The Science and Technology of Coal and Coal Utilization" 1984, Plenum Press, New York.
[9] Sarkar Samir, Second edition, Orient Longman Limited, Bombay. 1990.
[10] Tripathy Prem S., Mukherjee S.N. "Perspectives Of bulk use of fly ash", CFRI Golden Jubilee Monograph, Allied Publishers Limited 1997.

AUTHORS

First Author – Manjula Sharaff, Chemistry Department, CMDubey Postgraduate College, Bilaspur- 495001
E-mail: manjulasharaff@yahoo.com
Second Author – Sharad K. Vajpai, Chemistry Department, CMDubey Postgraduate College, Bilaspur- 495001
Third Author – Kiran Vajpai, Chemistry Department, Govt. Bilasa Girl's P.G. College, Bilaspur- 495001