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Erosion Problems in Fluidized Bed Combustion (fbc) Power Plant Based on Lakhra Coal

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The Fluidized Bed Combustion (FBC) technology is growing very fast. Due to its merits, first time this technology has been introduced in Pakistan by installing 3 x 50 MW power plant at Khanote. The (FBC) power plant at Khanote, based on Lakhra coal has been facing operational & technical problems, resulting in frequent shut down of generation units, hence causing heavy financial losses. This study reveals that due to the presence of high percentage of silica in lime stone supply, the generation tubes and wings / blades of Induced Draft Fan (IDF) were eroded, and filter bags were ruptured and resulting in frequently shut down of power generation units.

Keywords: FBC, power plant, erosion, Lakhra coal, Pakistan

Introduction

Pakistan has rich coal reserves and it is time to look for its proper utilization by installing power generation units based on Pakistani coal. Various investigators have worked on this technology for power generation (Douglas, 1977; Flemming, 2002; Tomczak,, 2002; Kevinclark, 2002; Knapp, 2000 & 2001). The first FBC power plant has been installed at Khanote based on Lakhra coal (Changdu and Sichvan, 1992, 1993); Power plant brochure, 1993). Lakhra coal is of low-grade lignite coal containing high percentage of moisture, ash and sulphur. The Lakhra coal based power plant is designed to generate 150 MW, but it has been observed that mostly all these three units are not available at the same time for parallel operation due to various operation/technical problems, such as erosion of generation tubes and wings/ blades of IDF, and rupturing of filter bags. The future of indigenous coal utilization for the power generation depends on the success of this plant.

This research has been under taken to study the root causes of the above mentioned operational/ technical problems.

Materials and Methods

Lakhra coal used at FBC (Hristov, 2002) power plant Khanote contains high percentage of sulphur. In order to avoid environmental problems created due to the presence of sulphur in coal, clean coal technology (FBC technology) has been used to capture sulphur by the addition of limestone.

Experimental work has been carried out in order to investigate the causes of erosion. The samples of limestone, bottom ash, fly ash and re-injection material have been analyzed. Ten samples of each material spread over a period of about twenty months were analyzed.

Lime Stone Analysis

Lime stone samples taken from sheds, conveyor belt (after crushing) and screw feeder (at the feed point to the reactor). Limestone used at FBC power plant Khanote has been analyzed for the determination of Calcium Carbonate ($CaCO_3$), Silicon di oxide (SiO_2), Aluminum Tri Oxide (Al_2O_3) and other components. The analysis data of limestone is given in Table 1.

Bottom Ash Analysis

Bottom ash samples were collected at the bottom of the FBC combustor after complete combustion of coal and limestone.Bottom ash samples obtained from FBC power plant Khanote were analyzed and results are given in Table 2.

Fly Ash Analysis

Fly ash samples were collected from the filter bag house. These samples have been analyzed for the determination of silica, calcium oxide and other components. The analyzed data is presented in Table-3.

Re-Injection (Un-Burnt Material)

These samples were collected through seal pot out let manifold. These samples have been analyzed for the determination of silica and other components. The analysis data is presented in Table-4

Results and Discussion

Lime stone analysis data have been presented in Table 1. It is observed from that about 10% of silica is present in the limestone used at FBC power plant. As per design and operational condition of the plant, zero percentage of silica is recommended. This silica is un-reactive of the operational conditions of the FBC reactor, so these particles moved around in the reactor and eroded the generation tubes as shown in Figure 1.
These silica particles are heavier than the other combustible material present in the reactor; so these particles are proportionally distributed in fly ash, bottom ash and re-injection material. Due to vigorous circulation of these particles, the maximum quantity of about 39% has been found in re-injection material Table 4. Due to high densityj of silica, about 34% has been found in bottom ash Table 2. Smaller particles of silica were carried through the fly ash and its percentage is about 24% Table 3.
These silica particles while passing through the ID fans have eroded the blades/wings of these fans as shown in Figure 2. It has been observed that these silica particles have also become the root cause of frequent rupture of filter bags.
In Figure 3 the average data of silica present in limestone, bottom ash, fly ash and re-injection material have been presented. It can be observed that presence of silica in lime stone have created many problems. Huge amount has been paid for the purchase and crushing of this unwanted material, efficiency of the plant has been badly affected, and the whole plant has been damaged and consequently frequent shut down of the plant occurred, which resulted in heavy losses.

Table 1. Limestone Analysis

S. No	Dates	*Loss of Ignition(* **LOI) (%age)**	*Silicon di oxide* **(Si_2O_2) (%age)**	*Aluminum tri oxide* **(Al_2O_3) (%age)**	*Ferrous tri oxide* **(Fe_2O_3) (%age)**	*Calcium oxide* **(CaO) (%age)**	*Magnesium oxide* **(MgO) (%age)**	*Sulphur tri oxide* **(SO_3) (%age)**
1	20.06.1997	37.49	09.50	00.56	00.48	50.49	00.80	00.17
2	10.09.1997	36.23	08.92	00.52	00.47	51.23	00.70	00.18
3	12.10.1997	38.75	10.12	00.61	00.49	49.75	00.90	00.16
4	02.01.1997	37.51	09.62	00.49	00.39	52:01	00.80	00.19
5	11.04.1998	37.47	09.42	00.63	00.57	48.97	00.60	00.15
6	12.07.1998	36.92	09.34	00.59	00.50	51.60	00.90	00.14
7	27.09.1998	38.06	09.70	00.53	00.46	49.38	00.80	00.20
8	18.11.1998	37.23	09.54	00.63	00.50	51.01	00.70	00.17
9	05.01.1999	37.75	09.50	00.49	00.47	49.97	00.80	00.17
10	10.03.1999	37.43	09.51	00.55	00.45	50.48	00.80	00.18
AVERAGE		37.49	09.52	00.56	00.478	51.59	00.78	00.176

Table 2. Bottom Ash Analysis

S. No	Dates	LOI (%age)	Si_2O_2 (%age)	Al_2O_3 (%age)	Fe_2O_3 (%age)	CaO (%age)	MgO (%age)	SO_3 (%age)
1	20.06.1997	06.35	33.66	16.20	25.60	10.59	00.60	05.89
2	10.09.1997	07.00	34.64	16.30	24.70	10.60	00.70	06.23
3	12.10.1997	06.82	33.69	16.80	24.20	11.30	00.40	06.73
4	02.01.1997	06.45	34.56	16.23	25.20	11.20	00.50	06.20
5	11.04.1998	07.23	32.20	16.20	24.20	10.23	00.80	06.11
6	12.07.1998	06.49	33.11	17.00	24.90	10.23	00.70	07.00
7	27.09.1998	07.13	32.36	16.39	25.30	10.90	00.60	05.90
8	18.11.1998	06.03	33.20	16.38	25.70	11.34	00.70	05.70
9	05.01.1999	06.33	34.55	16.34	24.90	11.39	00.50	06.80
10	10.03.1999	06.74	35.00	16.26	24.80	09.93	00.60	06.00
AVERAGE		06.65	33.37	16.41	24.95	10.77	00.61	06.25

Table 3. Fly Ash Analysis

S. No	Dates	LOI (%age)	Si_2O_2 (%age)	Al_2O_3 (%age)	Fe_2O_3 (%age)	CaO (%age)	MgO (%age)	SO_3 (%age)
1	20.06.1997	14.50	23.89	13.4	09.00	22.00	02.50	12.50
2	10.09.1997	14.40	22.93	13.20	08.70	21.20	02.40	13.00
3	12.10.1997	13.90	23.22	13.10	09.10	22.40	02.90	12.90
4	02.01.1997	14.70	24.12	14.00	08.23	21.50	02.80	12.70
5	11.04.1998	14.20	20.30	15.20	09.50	23.30	02.70	13.50
6	12.07.1998	15.20	23.50	13.70	09.00	23.40	02.30	13.20
7	27.09.1998	14.50	24.39	14.90	09.30	24.00	02.90	13.50
8	18.11.1998	14.70	24.39	14.90	09.80	23.70	03.50	14.00
9	05.01.1999	13.80	25.23	14.30	09.70	23.40	02.70	12.80
10	10.03.1999	14.90	24.33	14.50	09.20	24.00	02.40	13.20
AVERAGE		14.48	23.61	14.09	09.15	22.89	02.71	13.13

Table 4. Un-burnt (Re-Injection) Material Analysis

S. No	Dates	LOI (%age)	Si_2O_2 (%age)	Al_2O_3 (%age)	Fe_2O_3 (%age)	CaO (%age)	MgO (%age)	SO_3 (%age)
1	20.06.1997	02.38	39.50	29.35	18.40	05.05	01.48	02.90
2	10.09.1997	03.54	38.40	30.20	18.10	05.60	01.31	02.70
3	12.10.1997	03.24	39.20	30.60	17.90	05.80	01.92	03.10
4	02.01.1997	03.37	37.90	29.40	19.20	06.40	01.21	03.00
5	11.04.1998	02.77	38.90	29.40	18.30	05.90	02.34	03.50
6	12.07.1998	03.54	37.30	30.20	18.20	05.70	02.39	03.20
7	27.09.1998	03.55	37.32	30.90	19.30	06.70	03.20	02.90
8	18.11.1998	03.00	39.43	30.20	17.90	07.30	02.40	02.80
9	05.01.1999	03.55	39.51	30.80	18.90	08.70	01.38	02.50
10	10.03.1999	02.09	38.21	28.00	17.00	04.90	01.50	02.80
AVERAGE		03.10	38.54	29.00	18.32	06.20	01.91	02.94

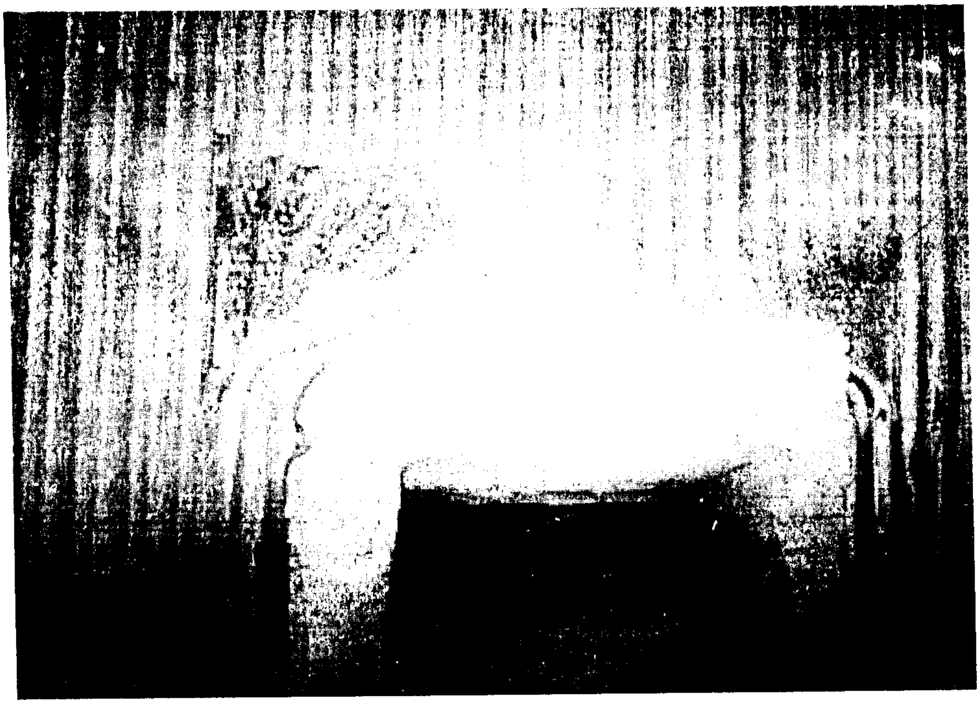

Fig 1. Erosion of Generation Tubes

Fig 2. **Erosion Of Wings Of I.D Fan**

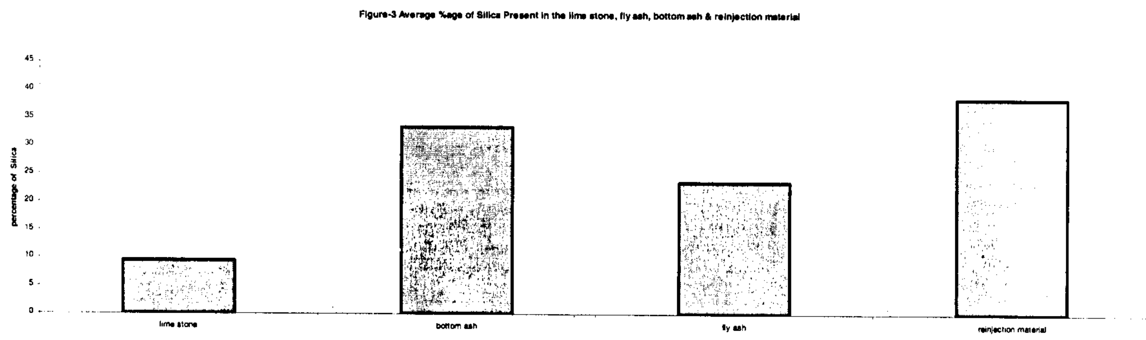

Fig 3. Average % Age Of Silica Present In Lime Stone, Fly Ash, Bottom & Reinjection Material

Conclusions

Following conclusions are made from this study:

•Low quality limestone containing about 10% silica has been used at the plant.
•Huge amount has been paid for the purchase, handling and crushing of unwanted silica material.
•Due to noncombustible property and rough shape of silica particles the generation tubes and wings/ blades of ID fans were eroded, and the filter bags were ruptured, resulting in frequent shut down of the plant, consequently heavy financial losses occurred.
•Due to the presence of silica, the efficiency of the FBC reactor was badly affected.
•Due to higher density of silica particles in comparison to other combustible material present in the reactor, these silica particles were proportionally distributed in fly ash, bottom ash and re-injection material.
•It was found that the maximum quantity of silica, *ie.* 39% in the re-injection material, about 34% in the bottom ash and 24% in fly ash was present.

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