

OPTIMIZATION OF COAL AND LIMESTONE RATIO USED IN FLUIDIZED BED COMBUSTION POWER PLANT AT LAKHRA

Shaheen Aziz*, Niaz Memon**, Suhail A. Soomro***

ABSTRACT

Due to rapidly population growth and urbanization, the power requirement is increasing every day. Thermal energy obtained from fossil fuels including coal is the prime source of power. Major part of coal reserve in Pakistan is of low-grade lignite coal containing high percentage of moisture, ash and sulphur. The low quality coal in Fluidized Bed Combustor plant at Khanote is the only power plant in Pakistan using low grade coal. Therefore its efficient utilization in proper manner is necessary in order to avoid Sulphur emissions. The effect of limestone on low grad lignite coal combustion in a fluidized bed combustor has been studied in the ratio as 5:1 to capture sulphur contents of coal. The results were compared with fluidized bed combustor in coal fired power plant at Khanote using limestone/coal ratio as 1:2. The study reveals that the limestone used in ratio of 1:5 to capture Sulphur content of coal during combustion produced almost same results when compared with ratio of 2:1 in Khanote power plant. In order to avoid various problems such as limestone preparation, bagging, transportation, handling and utilization in access, it is recommended that coal/ limestone should be 5:1 instead of 2:1.

1. INTRODUCTION

Fluidized bed combustion is the process where combustion occurs in a Fluidized bed. It is a latest technology used, especially for the utilization of low-grade coals containing high percentage of sulphur [1-2]. There are various combustor types used for the generation of electricity but research and experience shows that FBC is the best type of combustor for using low quality coals like lignite for generation of electricity. This type of combustor is environmentally safe, that's why it is also known as clean coal technology [3-4]. In the fluidized bed combustor, limestone has been used for capturing sulphur. In the bed, limestone is decomposed and reacts with sulphur dioxides in result gives calcium sulphate [5-10].

There are many advantages of fluidized bed combustion, but the main advantages are given below:

- Various low grade, high sulphur and, moisture containing coals can easily be used
- Low combustion temperature (800-950°C) can reduce the emissions of sulphur dioxide by addition of lime and can also reduce Nitrogen Oxide formation
- High heat transfer coefficient can make the required heating surface in a FBC smaller than that of a conventional boiler

- Fluidized bed combustion is environmentally safe [11-23].

The fluidization bed combustion (FBC) technology is in operation in Pakistan (3x50 MW power plant) at Khanote, Sindh, Pakistan [24-25].

Lignite type coals which are mainly used at Knaote contain high percentage of moisture, ash and sulphur. As mentioned above, limestone in FBC reactor is decomposed and reacts with sulphur dioxide and produce calcium sulphate. FBC reactor installed at Khanote is using 2:1 coal:limestone for the treatment which can be optimized to reduce the limestone load. This study is conducted to check if stoichiometric ratio of sulfur present in coal and limestone provides similar removal efficiency. The outcome of the study will help in alleviating not only operational and technical problems which occur frequently and ultimately lowers the efficiency of the power plant but also causes huge losses as a result of shut downs.

2. EXPERIMENTAL

Lakhra coal contains high percentage of moisture, ash and sulphur that is used in FBC power plant at Khanote, Sindh, Pakistan. Coal and limestone samples have been analyzed. The details of analysis are given below:

* Assistant Professor, Chemical Engineering Department, M.U.E.T, Jamshoro 76062 Pakistan
** Assistant Professor, Civil Engineering Department, QUEST, Nawabshah-67480
*** Professor, Institute of petroleum & Natural Gas Engineering, M.U.E.T, Jamshoro 76062 Pakistan

2.1 COAL ANALYSIS

(a) Proximate analysis

These types of analysis have been carried out on the compound basis. This analysis supplies readily meaningful information for coals use in stream generators. Proximate analysis determines the mass percentage of the compound i.e. moisture, volatile matter, ash and fixed carbon. Experimental work was carried out on the basis of the following methods.

(b) Moisture

About 1 gram of finally powdered air dried coal sample was weight in a crucible. The crucible was placed inside an electric hot air oven, maintained at 105-110 OC.

The crucible was allowed to remain in oven for 1 hour and then taken out with the help of pair of tongs, cooled in decicator and weighed. Then loss in weight was reported as moisture (on percentage) basis. The following formula was used as under.

$$\% \text{age of moisture} = (\text{loss in weight/wt.of coal taken}) \times 100$$

(c) Volatile matter

Sample was heated in the absence of oxygen in a standard test up to (954.4 OC for 7 minutes). This dried sample of coal left in the crucible was covered with a lid and placed in an electric furnace (Muffle furnace), maintained at 925+20 OC. The crucible was taken out of the oven after seven minutes heating; the crucible was cooled first in air then inside a decicator and weighted again. The loss in weight calculated by the following formula.

$$\% \text{age of volatile matter} = \frac{\text{loss in wt. due to removed of volatile matter} \times 100}{\text{Wt. of coal sample taken}}$$

(d) Ash

The residual coal in the crucible obtained after volatile method was then heated without a lid in a muffle furnace at (700+50 OC) for 1/2 hour. The crucible was then taken out, cooled first in air, then in decicator and weighed. Heating, cooling and weighing is reported till a constant weight is obtained. The residue was counted as ash on the percentage basis. Thus formula was as under:

$$\% \text{age of ash} = \frac{\text{Weight of ash left} \times 100}{\text{Wt. of coal sample taken}}$$

(e) Fixed carbon

Fixed carbon was an eliminated carbon that exists in coal. In proximate analysis its determination is approximated

by assuming it to be the difference between the original sample and the sum of volatile matter moisture and ash, the following formula was used as:

$$\% \text{ age of fixed carbon} = 100 - \% \text{ age of (moisture + ash + volatile matter)}$$

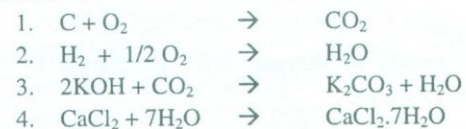
(e) . Ultimate analysis

The ultimate analysis of coal was carried out on the basis of element basis for precise the chemical determination. These include carbon, hydrogen, nitrogen oxygen and also sulfur. Ash was also included. The description is given as below:

(f) Carbon and Hydrogen

About 0.2 gram of accurately weighed coal sample was burnt in a current of oxygen in a combustion apparatus. Carbon and hydrogen of coal are converted into CO₂ and H₂O respectively. The gaseous products of combustion were absorbed respectively in KOH and CaCl₂ tubes of known weights. The increase in weights of these tubes was then determined. The reactions are as follows:

Reaction:



The formulas for finding percentages of carbon and Hydrogen are as given below.

$$\% \text{age of C} = \frac{\text{Increase in wt. of KOH in tube} \times 12 \times 100}{\text{Wt. of coal sample taken} \times 44}$$

$$\% \text{age of H} = \frac{\text{Increase in wt. of CaCl}_2 \text{ in tube} \times 2 \times 100}{\text{Wt. of coal sample taken} \times 18}$$

(g) Nitrogen

About 1 gram of accurately weighed powdered coal was heated with concentrated sulfuric acid along with potassium sulfate K₂SO₄ (catalyst) in a long necked flask (called kjeldihas flask) after the solution becomes clear, it is treated with excess of KOH and liberated ammonia is distilled over and absorbed was known volume of standard acid solution. The unused acid was then determined by back titration with standard NaOH. From the volume of acid used by ammonia liberated. The percentage of nitrogen in coal have been calculated by the following formula.

$$\% \text{age of N} = \frac{\text{Volume of acid used} \times \text{normality} \times 14}{\text{Wt. of coal taken}}$$

(h) Sulphur

It is determined from the washings obtained from the taken mass sample of coal used in a bomb calorimeter for determination of calorific value. During this determination sulphur was converted into sulphates. The washings are treated with barium chloride solution. Then precipitated barium sulphate was, filtered washed and heated to constant weight. The following formula was used for the determination of Sulphur.

$$\% \text{age of S in Coal} = \frac{\text{wt. of BaSO}_4 \text{ contained} \times 32 \times 100}{233 \times \text{Wt. of coal sample taken in bomb}}$$

(i) Ash

The % age of ash determination was same as it was determined in the proximate analysis.

(j) Oxygen

The percentage of oxygen was determined by the following formula:

$$\% \text{ age of O}_2 = 100 - \% \text{ age of (C + H + O + N + ash)}$$

2.2 LIMESTONE ANALYSIS

Analysis of the Limestone was carried out by using the following methods:

(a) Loss on ignition

Weigh about a 0.5-g specimen of the prepared sample to the nearest 0.001 g into a clean, previously ignited and weighed, covered platinum crucible. Heat slowly at first to avoid loss by decrepitation, finally to constant weight at 1000°C, in the muffle furnace. (Usually 1 h is sufficient for complete ignition.) Cool in a desiccator and report the loss in weight as the loss on ignition.

(b) Silica oxide

Transfer the previously-ignited residue quantitatively to a 300-mL porcelain casserole. Carefully slake with about 10 mL of water, and mix to a slurry with a flat-end glass stirring rod. Add 5 to 10 mL of concentrated HCl and digest with gentle heat until solution is complete, carefully breaking up any lumps. Evaporate to dryness and bake the residue on a sand bath or in an oven for 1 h.

If the MgO content is high (10% or over on the nonvolatile basis), bake at 120°C; if below 10% MgO, bake at 200°C. (The high dehydration temperature is efficient for low MgO, but with high MgO, silica redissolves at temperatures over 120°C). Cool to 40°C or lower, drench with concentrated HCl and allow to stand a few minutes. Then add an equal amount of water, cover the casserole, and heat on the steam or sand bath for about 10 min. Filter through an 11-cm filter paper into a 400-mL beaker. Wash the residue thoroughly with HCl (1:10) and then wash twice with hot (about 60-90°C) water. Pour the filtrate back into the same casserole, evaporate to dryness, treat with HCl and water as before, filter through a second filter paper of the above type and wash twice with hot water. Save the filtrate.

Transfer the wet papers to a previously ignited and weighed platinum crucible, char carefully without allowing the paper to flame, and finally ignite in the muffle furnace to constant weight at 1000°C (30 min is usually sufficient). Cool in a desiccator and weigh. Fuse the residue in the crucible with a little Na₂CO₃ (1 to 2 g), cool the melt, dissolve in 1:1 HCl, and add the solution to the filtrate from silica and insoluble matter.

(c) Alumina

Subtract the Fe₂O₃ from the weight of the Fe₂O₃ + Al₂O₃ and calculate the remainder to percentage of Al₂O₃.

(d) Iron oxide and alumina (R₂O₃)

To the acid filtrate from the silica determination, add a few drops of bromine water or concentrated HNO₃ and boil until all traces of bromine or chlorine are gone. Add enough concentrated HCl so as to have a total volume of 10 to 15 mL of the concentrated acid. Add a few drops of methyl red solution, dilute to 200 to 250 mL, and heat to boiling. Carefully neutralize with concentrated NH₄OH until the color changes to a distinct yellow. Boil for 1 or 2 min, let settle, and filter into a 600-mL beaker. Wash four times with hot 2% NH₄Cl solution. Save the filtrate.

Place the beaker in which the precipitation was made under the funnel containing the precipitate. Dissolve the precipitate on the paper with about 15 mL of 1:1 HCl; wash the paper thoroughly with hot water. Heat, neutralize with NH₄OH, and boil as in the first precipitation. Filter (the same paper may be used) and wash four times with hot 2% NH₄Cl solution. Place the

paper in a previously ignited and weighed platinum crucible, char without allowing the paper to take fire, and finally ignite 30 min at 1000°C in the muffle. Cool in a desiccator and weigh as R₂O₃.

(e) Calcium oxide

Combine the two filtrates from the iron oxide plus alumina determination. Make just acid to methyl red with concentrated HCl, then add 2 mL of the acid in excess. Evaporate to 350 mL, add 20 mL of 10% oxalic acid and boil. To the boiling solution add 1:3 NH₄OH dropwise from a pipet until a precipitate begins to form. Now add the NH₄OH still more slowly, allowing most of the precipitate to form between each addition. Continue until the methyl red just turns yellow. Add 25 mL saturated ammonium oxalate and stir. Let the solution stand and cool for 1 h.

$$\text{CaO, \%} = \frac{(\text{mL KMnO}_4) \times (\text{Normality}) \times 2.804}{\text{Weight of sample in grams}}$$

(f) Magnesium oxide

Acidify the filtrate from the calcium oxalate precipitation and evaporate to about 450 mL. Cool to room temperature. Add 30 mL of a freshly prepared 10% solution of (NH₄)₂HPO₄. Add a few drops of methyl red, stir vigorously, and add concentrated NH₄OH slowly—especially while the precipitate is still forming—until the solution is alkaline to the methyl red. Now add 10 mL of concentrated NH₄OH for each 100 mL of solution. Stir vigorously a few times at about 15-min intervals. Let settle overnight.

Filter through a tared Gooch crucible, transferring all the precipitate to the crucible with the aid of a rubber policeman. Wash with cool 5% NH₄OH. Ignite in a muffle furnace, starting at 300°C, gradually increasing the heat to 1000°C. Hold at 1000°C for 1 h. Cool in a desiccator and weigh as Mg₂P₂O₇. Calculate the MgO as follows:

$$\text{MgO, \%} = \frac{\text{Weight of Mg}_2\text{P}_2\text{O}_7 \times 36.21}{\text{Weight of specimen}}$$

3. RESULTS & DISCUSSIONS

3.1 STOICHIOMETRIC REQUIREMENT OF COAL-LIMESTONE

The basis of stoichiometric calculation was taken as 100 kg of coal that contains 6% sulphur.

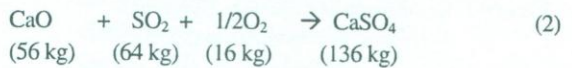


As per equation (1), 32 kg of Sulphur reacts with 32 kg of O₂ to produces 64 kg SO₂.

$$\begin{aligned} \text{Hence 6 kg of sulphur will produce} &= (64/32 \times 6) \\ &= 12 \text{ Kg of SO}_2 \end{aligned}$$

It means 6 Kg of sulfur produces 12 Kg of SO₂.

The SO₂ produced through reaction (1) will react with CaO and oxygen to produce CaSO₄ as shown in reaction (2) as follows:



From reaction (2), it is clearly shown that 64 Kg of SO₂ require 56 Kg of CaO so 12 Kg of SO₂ requires:

$$\begin{aligned} &= (56/64) \times 12 \\ &= 10.5 \text{ Kg of CaO} \end{aligned}$$

Therefore, 10.5 kg CaO is required to capture all Sulfur present in 100 Kg of Coal.



56 kg of CaO produced from 100 kg of CaCO₃.

10.5 kg of CaO produce 18.75 kg (100/56 x 10.5)

Therefore, CaCO₃ = 18.75 kg

Lime Stone having 95% CaCO₃

95 kg. CaCO₃ ----- 100 kg Of lime Stone

Therefore

18.75 kg. CaCO₃ ----- 100/95 x 18.75 = 19.74 kg of lime Stone.

Therefore, for 100 kg coal having 6 kg (6%) sulphur will require 19.74 kg.

Lime Stone having 95% CaCO₃.

Therefore Coal-lime stone ratio is 100:20 or 5:1.

In table-1, the result clearly shows 6% of sulphur present in coal. The limestone is being used to capture the Sulphur (6%) present in the coal. Practically, in the power plant, coal-limestone ratio of 2:1 is being used. But as per stoichiometric requirement that has been shown above as per above calculation it shows that coal-limestone ratio should be 5:1 that is required for capturing of sulphur (6%) present in coal. Figure. 1 gives the comparison between amounts of limestone required actually with that required stoichiometrically.

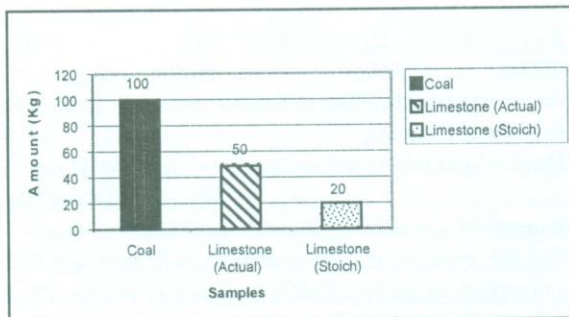


Figure 1: Comparison of Limestone Usage with Actual and Stoichiometrical Calculations

3.2 OTHER FACTORS AFFECTING THE EFFICIENCY OF FBC

As per specification of the FBC, coal & limestone must go through a process of crushing & grinding in order to get the proper size of the material to be burnt in the FBC. As it was noticed that, there is 150% excess limestone used that is to be crushed, it not only causes energy loss but also extra financial burden on the FBC plant.

Excess of limestone create various problems in the FBC that includes the formation of bottom ash & fly ash that ultimately causes maintenance, handling & disposal problems.

Due to the improper ratio of limestone supply, the generation tubes and wings/ blade of I.D fans were eroded. Filter bags were also ruptured and resulting in frequent shut down of power generation units.

4. CONCLUSIONS

As per stoichiometric requirement 5:1, coal / limestone ratio is required, but practically in FBC in the power plant 2:1 is being used. This shows 150% excess quantity of limestone is being used. Huge amount is being wasted for 150% excess quantity of limestone. The excess amount of limestone not only causes loss of money but also causes various problems including damage of FBC internal chamber walls, ID Fans that affect the efficiency of power plant.

RECOMMENDATIONS

- The ratio of coal and limestone should be used on the basis of Sulphur contents.
- Due to higher percentage of particles in the flue gases the blades/wings of I.D fans are being eroded.

- Regular analysis of the following should be done for the determination of Sulphur compounds and calcium oxide.
 - Coal particle size at feed point
 - Limestone particle size at feed point
 - Fly ash composition
 - Bottom ash composition
 - Re-injection (un-burnt material) composition
 - Flue gases composition

REFERENCES

- [1] Douglas, M, "Energy Technology", Hand Book, Conceding Edition, Mc Graw Hill, New York, 1977.
- [2] Lopez, S. B, Bohm, V. N, "Public policy for energy technology innovation - A historical analysis of fluidized bed combustion development in the USA", J. Energy Policy, no. 30, 1173 -1180, 2002.
- [3] The Coal Industry Advisory Board, "The Use of Coal in Industry", International Energy Agency, OECD, Paris, 1982.
- [4] Yang, W.C, Handbook of fluidization & fluid particle systems (chemical industries), 2007.
- [5] Begic, F, Afgan, N. H, "Sustainability assessment tool for the decision making in selection of energy system - Bosnian case", available on line on www.sciencedirect.com , J Energy, 2007.
- [6] Nam, C. H, Pfeffer, R, "Acrated vibro-fluidization of silica nano-particles", published online, Wiley inter science, vol. 50, no.8, August 2004.
- [7] Go'ra, D., Anthony, E.J., Bulewicz, E.M., 'Steam reactivation of 16 bed and fly ashes from industrial-scale coal-fired fluidized bed combustors', J Fuel, 85, 94-106, 2004.
- [8] Ferrer, E., Aho, M., Silvennoinen, J., Nurminen, R., "Fluidized bed combustion of refuse-derived fuel in presence of protective coal ash", J. Fuel Processing Technology 87, 33 - 44, 2005.

- [9] Knapp, R, "Clean Coal use- a Reliable Option Sustainable Energy Developments", Workshop organized by the Central Mining institute and UNECE in Szczyrk, Poland-24-26, May 2001. and power production Boiler", IFRF journal in May-2002.
- [10] Knapp, R, "Energy and Environment in the 21st century- challenges and cooperation in the Asia pacific region", (session B3 Environment, B3 clean coal Technology) held in Toyo- 18-19 October 2000.
- [11] Changdu and Sichvan, " 3x50 MW FBC Lakhra power plant Near Khanote", Dong Fang Electric corporation, R. of China, 1993.
- [12] Changdu and Sichvan, "The structure, operation and Maintenance of 220 t/hr Fluidized Boiler", Dong Fang Electric corporation, Book-I, Rep. of China, 1992.
- [13] Water and Power Development Authority, Brochure, "150 MW Lakhra Power station Near Khanote", 1993.
- [14] Martin. C, Villamanan, M. A, Chamorro, C. R, Otero. J, Cabanillas. A, Segovia J. J., "Low-grade coal and biomass co-combustion on fluidized bed: energy analysis", J. Energy 31, 330-344, 2006.
- [15] Takuwa. T, Naruse. I, "Emission control of sodium compounds and their formation mechanisms during coal combustion", Proceedings of the Combustion Institute 31, 2863 -2870, 2007.
- [16] Manovic. V, Grubor, B., Loncarevic, D., "Modeling of inherent SO₂ capture in coal particles during combustion in Fluidized bed", J Chemical Engineering Science 61 ,1676 -1685, 2006.
- [17] Ishom,F., Harada, T., Aoyagi, T., Sakanishi, K., Korai, Y., Mochida, Isao., "Problems in PFBC boiler (2): characterization of bed materials found in a commercial PFBC boiler at different load levels", J. Fuel 83, 1019-1029, 2004.
- [18] Flemming.F "Deposit formation and corrosion in the air preheater of a straw fired combined Heat and power production Boiler", IFRF journal in May-2002.
- [19] Aziz .S, Pathan., M.I., Soomro, S.A, "Erosion Problems in FBC Power Plant Based On Lakhra Coal", J.Appl. & Emerg. Sc., Vol. 1, No.03, P-145, 2006.
- [20] Valentim, B., Lemos de Sousa, M.J., Abelha., P., Boavida,D., Gulyurtlu, I., "The identification of unusual microscopic features in coal and their derived chars: Influence on coal fluidized bed combustion", International Journal of Coal Geology 67, 202- 211, 2006.
- [21] Zhou, H., Flamant, G., Gauthier, D.,, "DEM-LES simulation of coal combustion in a bubbling fluidized bed Part II: coal combustion at the particle level", Chemical Engineering Science 59, 4205 -4215, 2004.
- [22] Zhou, H., Flamant, G., Gauthier, D., "DEM-LES of coal combustion in a bubbling fluidized bed. Part I: gas-particle turbulent flow structure", Chemical Engineering Science 59, 4193 -4203, 2004.
- [23] Dennis J.S, Hayhurst, A.N., Scott, S.A., "The combustion of large particles of char in bubbling fluidized beds: The dependence of Sherwood number and the rate of burning on particle diameter", J. Combustion and Flame, 147, 185-194, 2006.
- [24] Raffle, M., Willert, C.E, Wereley, S. T, Kompenhans, J, "Particle image velocinmetry: A practical guide (experimental fluid mechanics)", 2nd revised edition, June 2007.
- [25] Aziz .S, "study of technical aspects for improving the efficiency of FBC power plant at Khanot" M.E Thesis, Chemical Engineering Department, Mehran University of Engineering & Technology, Jamshoro, 1999.D. Broadbent, "Reactive dyes," in *Basic principles of textile coloration*, A. D. Broadbent, Ed., First ed: Society of Dyers and Colourists, pp. 332-357, 2005.

Table 1: Proximate Analysis of Coal

S.#	Calorific Value (Kcal/kg)	Sulphur	Moisture (% age)	Ash (% age)	Volatile Matter (% age)	Fixed Carbon (% age)
1.	3336	06.73	16.90	30.05	26.03	21.51
2.	3297	06.23	16.94	30.23	27.15	21.93
3.	3315	05.78	16.45	31.84	25.54	20.34
4.	3225	06.12	16.33	30.34	26.91	21.93
5.	3296	05.96	16.51	30.41	26.92	21.73
6.	3190	05.86	16.30	30.91	25.32	21.45
7.	3217	06.12	16.20	30.74	26.01	20.31
8.	3189	06.23	16.09	31.38	25.40	20.39
9.	3219	06.25	16.31	30.29	26.50	21.13
10.	3326	05.92	16.57	31.91	25.03	21.20
11.	3251	05.78	16.14	30.01	26.21	20.20
12.	3295	06.69	16.31	30.12	26.59	21.50
13.	3293	06.15	16.14	30.13	26.89	21.50
14.	3253	06.31	16.75	31.03	26.30	20.90
15.	3292	06.21	16.39	30.05	26.89	20.30
Average	3266	06.15	16.42	30.62	26.41	21.02

Table 2: Ultimate Analysis of Coal

S.#	Moisture (% age)	Ash (% age)	Sulphur (% age)	Carbon (% age)	Hydrogen (% age)	Nitrogen (% age)	Oxygen (% age)
1.	08.49	30.00	05.39	38.99	07.54	00.70	08.890
2.	32.00	19.52	05.20	33.04	02.45	00.75	07.040
3.	30.76	12.44	05.32	40.31	03.09	00.76	07.510
4.	32.46	06.49	03.32	45.70	03.48	00.92	07.630
5.	29.86	06.50	04.31	47.17	03.61	00.89	07.660
6.	30.65	10.14	05.23	42.10	03.35	00.73	07.350
7.	29.75	11.15	04.25	41.81	03.34	00.39	07.890
8.	30.45	10.75	04.23	41.91	03.93	00.65	07.130
9.	29.35	10.85	04.92	42.21	03.45	00.78	07.390
10.	30.25	09.35	04.31	40.20	03.41	00.97	07.210
Average	28.40	12.71	05.07	41.34	04.11	00.75	07.57

Table 3: Analysis of Limestone

S. #	LOI (% age)	SiO ₂ (% age)	Al ₂ O ₃ (% age)	Fe ₂ O ₃ (% age)	CaO (% age)	MgO (% age)	SO ₃ (% age)
1.	37.49	09.52	00.56	00.48	50.49	00.80	00.17
2.	36.23	08.92	00.52	00.47	51.23	00.70	00.18
3.	38.75	10.12	00.61	00.49	49.75	00.90	00.16
4.	37.51	09.62	00.49	00.39	52.01	00.80	00.19
5.	37.47	09.42	00.63	00.57	48.97	00.60	00.15
6.	36.92	09.34	00.59	00.50	51.60	00.90	00.14
7.	38.06	09.70	00.53	00.46	49.38	00.80	00.20
8.	37.23	09.54	00.63	00.50	51.01	00.70	00.17
9.	37.75	09.50	00.49	00.47	49.97	00.80	00.17
10.	37.43	09.51	00.55	00.45	50.48	00.80	00.18
Average	37.484	9.519	0.56	0.478	50.489	0.78	0.171