Chemical Technology
ISSN: 0974-7443

Chemical Technology: An Indian Journal

Research | Vol 17 Iss 3

Sulfur Capturing Efficiency of Dolomite by using Eschka Mixture Method

Nabeel Rana[*]
Department of Chemistry, Indian Institute of Technology Delhi, India
[*]**Corresponding author:** Nabeel Rana, Department of Chemistry, Indian Institute of Technology Delhi, India; E-mail: nabeelrana76@gmail.com

Received: January 14, 2022, Manuscript No. TSCT-22-49178; **Editor assigned:** January 17, 2022, PreQC No. TSCT-22-49178 (PQ); **Reviewed:** January 31, 2022, QC No. TSCT-22-49178; **Revised:** March 14, 2022, Manuscript No. TSCT-22-49178 (R); **Published:** March 31, 2022

Abstract

This research investigated the effectiveness of Pakistani dolomites in capturing sulfur from Makarwal coal samples using Eschka mixture method. Makarwal coal was found to contain moisture 3%, ash 29%, volatile matter 30%, sulfur 5.4%, and fixed carbon 38% and GCV 4900 kcal/kg. Three types of dolomites from Kalarkahar, Jhelum and Mianwali regions were tested with different coal to dolomite ratios (1:1, 1: 2, 1:3, 1:4, 1:5, 1:6, and 1:7). Both calcined and non-calcined dolomites and calcium carbonates were tested and compared in this study. The standard Eschka method was adopted for determination of sulfur in combusted coal sulfur. A blank run was conducted using standard MgO/Na_2CO_3 reagents for sulfur determination. It was found that the sulfur captured efficiency of all dolomites increased by increase dolomite ratio and optimum results were obtained at higher ratios of 1:6 and 1:7. Dolomite can be used for capturing of sulfur in low grade coal i.e. in which sulfur is present up to 4%. It is also noticed that dolomite on decarboxylation can release more calcium oxide which is active site for capturing for sulfur as compared to calcium carbonate. Abbottabad dolomite shows more effectiveness as compared to other dolomites in both calcined and non-calcined form.

***Keywords:** Dolomite Abbottabad; Dolomite Calcined Abbottabad; Dolomite Kalarkahar; Dolomite Calcined Kalarkahar; Dolomite Mianwali; Dolomite Calcined Mianwali*

Introduction

There are two main analysis of coal which is proximate and ultimate analysis. For this analysis the analytical conditions are prescribed by ASTM. The main proximate analysis is ash, moisture, volatile matter and fixed carbon. Fixed carbon and ash are material that not vaporizes when these are heated in the absence of air. Fixed carbon is determined by the sum of other three values that are moisture, volatile matter and ash subtracting from 100 percent. The main reason to know the value of ash and moisture is that these do not contribute in heating value of coal. Somehow ash is also considered undesirable product and major source of pollution, but it may be used for chemical feed stock, cement formation and liquefaction and mineral matter may be desired [1].

The total coal reserves of Sindh province are 184 billion tones. Lignite and sub-bituminous basic form of coal found in Sindh. In Thar, a large coal field in east part of the province that has the resource of about 175 billion tons of coal. Geological department of Pakistan made a survey report on Thar deposit in detail. The coal seam ranges in thickness 11.5 meters to 20 meters, at an average 50 meters being loose sand. The rank of coal is the lignite and sub-bituminous rank [2].

Lakhra coal field spread approximately over an area of 200 sq. Km and this field has been connected through roads and railways with cities like Karachi and Hyderabad. Mostly underground mining has been conducted in this area. The basic rank of coal mostly found in Lakhra is of lignite and sub-bituminous. The coal contains about 30 percent moisture and amber resin flakes and is dull black. Although when brought to surface it dries to about 8 percent moisture and it can be extracted as large lumps. Average annual Lakhra coal production is 1 million tones and has been used in industrial brick kilns mostly [3].

Citation: Rana N. Sulfur Capturing Efficiency of Dolomite by using Eschka Mixture Method. Chem Tech Ind J. 2022;17(3):001
© 2022 Trade Science Inc.

Gas which is generated during combustion process is known as flue gas. The composition of flue gas depends on the combustion condition and type of fuel used and air to fuel ratio is also important. The components of flue gas are air pollutant and these components should be minimized by special cleaning procedure before the gas is released in the air [4].

Nitrogen is considered to be major constituent of air and by volume it is 79% in air. Nitrogen is odorless, colorless, and tasteless gas. During combustion process, nitrogen is fed with combustion air and it does not take part in the combustion process. However, the minor quantities of air are combined with nitrogen that released from fuel. Nitrogen is responsible for the formation of hazardous nitrogen oxides [5].

Carbon dioxide is odorless and colorless and tasteless gas. During the combustion process of the fuel and by respiration process carbon dioxide produced. Carbon dioxide contributes to the greenhouse effect the ability of filter heat radiation. During the combustion process oxygen is consumed that especially present in air and it helps for combustion process. If sulfur or nitrogen also present in coal, then it can cause to form their oxides which are very harmful and can cause acid rain [6].

During the combustion process, the nitrogen containing fuel, during combustion process nitrogen reacts with oxygen of the air and it produces nitric oxides. A lot of technologies are available to clean flue gas from NOx, such as selective catalytic process. Like other combustion gases sulfur dioxide is a toxic, colorless gas with pungent smell. Sulfur dioxide forms by the oxidation of sulfur in fuel. Sulfur dioxide is very harmful gas and it causes acid rain. Sulfur dioxide can be reduced form scrubbing technologies [7].

Dolomite is a sedimentary rock which is made up of anhydrous Ca.Mg $(Co_3)_2$ in natures. Geologist can be distinguished between dolomite and dolostone; as dolomite is metamorphic rock while dolostone is result of sedimentary rock. If lime stone contains some amount of dolomite it is called dolomite limestone. In fact, it is also called mineral rock. Dolomite is very seldom found in newly sedimentary environments however dolomite is very common in the records of rocks. These rocks are mostly very thick and about hundred to thousand feet. Mostly rocks that contain higher quantity of dolomite were deposited as calcium carbonate mud’s that were post depositional changed by magnesium rich water that enter into the pores of calcium carbonate to form dolomite. In hydrothermal veins dolomite is very common mineral. Dolomite is often associated with pyrite, barite, chalcopyrite, fluorite, sphelerite and galena. These veins often found as rhombohedral crystals and sometimes in curved faces [8].

It is the commonest type of mineral. It is made up of Ca.Mg $(CO_3)_2$, so it is also known as limestone of the calcium magnesium carbonate. It is found in the earth crust in combined form such as aragonite and calcite, about 2%. It was named after a French mineralogist as well as geologist name Deodat de Dolomieu (1750-1801).

It is found in crystal form and also in the form of sedimentary rock under the ground nearly about several hundred feet crystals can be formed in rhombohedral form, transparent, shiny, and somehow dull. It can be found in different colors such as white, brownish white, pink as well as reddish white.in the pulverized form, it can be easily dissolved in warm acids. Such as HCL or H_2SO_4. Dolomite reserves found in different regions under the world such as in USA, Canada, Ontario, Mexico, Ontario, Spain, Pamplona [9].

Laboratory/artificial dolomite

According to the general principle which are governing to the course of irreversible geochemical reaction following the breaking by Ostwald step rule, there are two phases of dolomite formation, first one is the dissolution while second one is the re-precipitation, reproducible, inorganic low temperature synthesis of dolomite and magnetite were published in 1999 in which it was shown that how less stable precursor (such as magnesium calcite) can be converted into more stable phase, such as (dolomite/magnetite) during periodically intervals of dissolution and re-precipitation (FIG.1) [10].

FIG.1. **Types of dolomites.**

Chemical components

Dolomite is composed of 13.18% magnesium, 21.73% calcium, 13.03% carbon, 52.06% oxygen, manganese carbonates, Iron, and lead barium are sometimes present as impurities [11].

General use of dolomite

There are following uses of dolomite illustrated in the given below FIG.2.

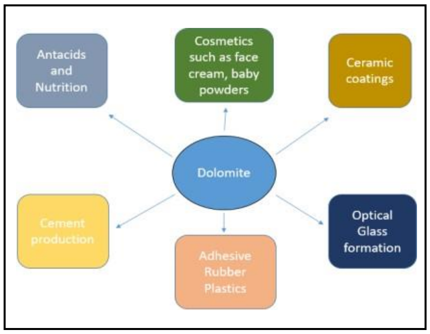

FIG.2. **Uses of dolomite.**

In calcium carbonate the highest concentration of calcium by weight is 40% and this form of calcium is comparatively insoluble and can be problematic to break down in the body. Calcium citrate is more soluble and it contains half calcium and by weight it contains 21%. Citrate is better source of calcium (TABLE 1).

Chemical properties

The chemical properties of calcium carbonate are as follows,

- Calcium carbonate treated with acid give CO_2
- $CaCO_3(s) + 2H+ (aq) \rightarrow Ca_2+ (aq) + CO_2 (g) + H_2O (l)$
- When it is heated at high temperature it can release CO_2, so this process is also known as calcination. And it forms CaO (quick lime), which is soluble in the water.
- (to above 840°C in the case of $CaCO_3$), with reaction enthalpy 178 kJ / mole:
- $CaCO_3 (s) \rightarrow CaO (s) + CO_2 (g)$
- $CaO + H_2O \rightarrow Ca(OH)_2$
- Calcium carbonate will also cause temporary hardness in the water by capturing CO_2 from the atmosphere
- $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

It can also lead to the erosion of the calcite rocks [12].

TABLE 1. **Physical properties.**

Shape	Hexagonal
Smell	Odorless
Density	2.71-2.83mg/l
M.P	825-1339c
Forms	Calcite, aragonite, chalk

Experimental works

The experimental work on coal and dolomite was performed under following steps:

Proximate analysis

Experimental work was performed to analyze the gaseous emission from using dolomite in different ratios with coal. While proximate analysis of coal includes the approximation of moisture, volatile matter, ash and fixed carbon content (FIG.3) [13].

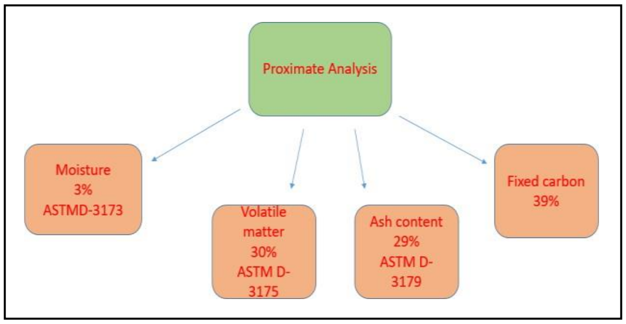

FIG.3. **Proximate analysis.**

Moisture calculation

Procedure

Moisture in coal is determined by ASTM standard D-3173. According to this standard 1 gram of coal sample taken into pre-weighed Petri dish. Place this dish into moisture oven at 110°C for 1 hour. After 1 hour remove the Petri dish from oven and cooled in the desiccator. After that weight of Petri dish also noted.

Moisture %age=Total weight loss on heating weight of sample taken×100

Calculations:

- Weight of coal sample=1 g
- Weight of empty petri dish=19.60
- Weight of sample with petri dish before heating=20.60
- Weight of sample with petri dish after heating=20.57
- Weight loss on heating = 0.03
- Moisture %age=20.60-20.57 1 × 100
- Moisture %age=3

Volatile matter

Procedure

Volatile matter in coal is determined according to ASTM standard D-3175. According to this 1g of coal sample taken into pre-weighed crucible and covered with lid. Then place this crucible into furnace at temperature 950°C for 7 minutes. After that remove the crucible from furnace. Place this crucible in the desiccator so that it cools down [14]. Then weight of crucible noted.

Volatile matter % age=weight Difference-Loss in weight of sample during moisture test weight of sample taken × 100

Calculations:

- Weight of coal sample=1 g
- Weight of empty crucible with lid=30.53
- Weight of sample with crucible before heating=31.53
- Weight of sample with crucible after heating=31.23

- Volatile matter %age=31.53-31.23 1 × 100
- Volatile matter %age=30

Ash content

Procedure

Ash in coal is determined according to ASTM standard D-3174. According to this 1 gram of sample taken in the pre-weighed crucible and placed into furnace at temperature 750°C for 2 hours. After 2 hours of continuously heating, crucible removed from furnace and placed in the desiccator for about 20 minutes. When the crucible cools, then weigh the crucible using weight balance [15].

Ash percentage in coal=weight of crucible sample after heating weight of empty crucible weight of sample taken × 100

Calculation:

- Weight of coal sample=1 g
- Weight of empty crucible=35.68g
- Weight of sample with crucible before heating=36.68g
- Weight of sample with crucible after heating=36.39g
- Ash %age=36.68-36.39 1 × 100
- Ash %age=29

Fixed carbon determination

Subtract Total moisture, volatile matter content and ash content from 100
Percentage of fixed carbon=100-(%of total moisture + % of volatile matter + % of ash content)
Fixed Carbon=100 - (3+30+29)
Fixed Carbon=38%

Procedure

Calorific value of coal sample was determined by using bomb calorimeter as follow. 1-1.5 g of coal sample was taken and compressed into circular pallet by using presser machine. Coal pallet was placed into crucible of calorimeter. A piece of firing nichrome wire was stretched across the inner terminal of bomb. The bomb was charged with oxygen to a pressure of 25 atm through needle valve without displacing the original air. The calorimeter vessel was then charged with a weighted quantity of water (usually 2.5 liter) to submerge the bomb up till cover completely. The bomb was then placed in the calorimeter after complete insurance of its tightness. Beckmann's thermometer was adjusted along with cover of calorimeter and then stirrer started and allowed to run for 5 minute before observation to begun. The button was pressed for firing by which burning of sample was started. Temperature on thermometer was read till it stops rising. By burning of sample temperature of water was read as delta T (Final temperature-Initial temperature) [16].

- GCV=[(WE + M) CP × ΔT]/wt. of sample

Where as

- WE=Water Equivalent
- M=Mass of Water used
- Cp=Specific Heat of Water at Room Temperature
- $\Delta T = T2 - T1$ (Change in Temperature)
- T1=Initial Temperature
- T2=Final Temperature

Sulfur capture by Eschka mixture method

Procedure

The 4 g of Eschka mixture was prepared by taking 2.667 grams of calcined MgO and 1.33 g of sodium carbonate and mixed well. That was Eschka mixture for 1 g sample testing. Every time fresh Eschka mixture was made for each testing. The 1-gram sample of coal was taken and 3 g of eschka mixture from the above 4 grams' mixture in crucible and mixed well. Mixture was covered with 1 g remaining Eschka mixture. Crucible was put into cold furnace and raised the temperature gradually up to 800 ± 25°C the above temperature was maintained for one and half to 2 hours and then crucible was taken out from the furnace and checked by stirring the sample. If the black particles were not found, indicated that combustion has been completed. The crucible was cooled in the desiccator and emptied in the 200 ml beaker and digested with 100 ml distilled water [17].

After that the solution was filtered using Whatmann filter paper. The filter paper was washed out using hot water and washings were giver five to six times and makes volume up to 250 ml. Then 2 drops of methyl orange added in the solution and then neutralized with 10%, 10 ml solution of anhydride sodium hydroxide. Concentrated HCl added drop by drop until the color of the solution changes from light yellow to pink. Then solution was boiled and add 10 ml of 10% barium chloride drop by drop. The solution was boiled for about 15 minutes and kept the solution for about 2 hours. The precipitates in the solution were settle down.

Then filter the solution using whatmann filter paper. 10 to 15 washings were given to residue. In the filtrate concentrated $AgNO_3$, it was added until no more than a slight opalescence. The wet filter paper containing the precipitates of $BaSO_4$ was placed in the weighted porcelain crucible (FIG.4) [18].

Then smoked off the filter paper at 400°C on the hot plate at and burned out the filter paper at about 800°C for 30 minutes. Then remove the crucible from the furnace and cooled in the desiccator and weigh this crucible. The sulfur content in coal calculated as.

A=Grams of $BaSO_4$ residue
B=Grams of $BaSO_4$ correction
C=Weight of coal sample taken
Factor=13.738
Sulfur present in the sample=A-B C × 13.738

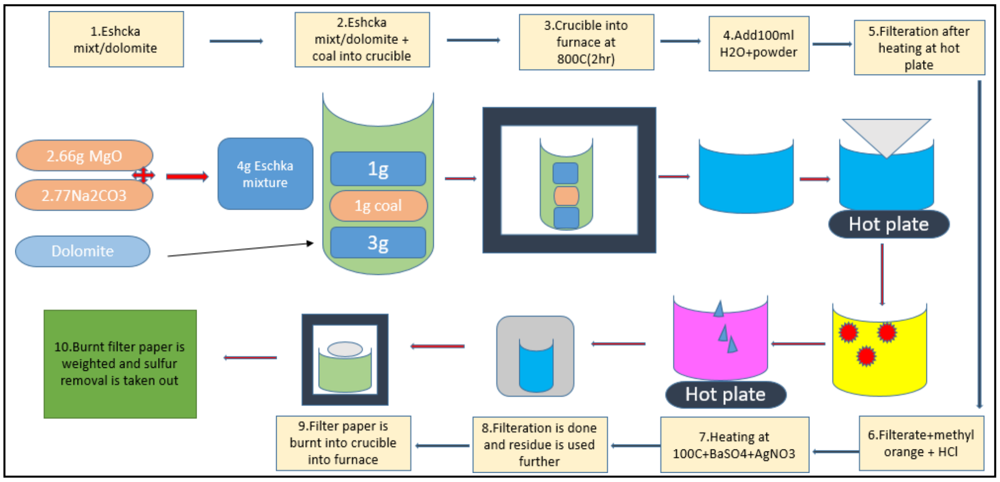

FIG.4. **Schematic flow sheet for sulfur removal by Eschka mix method.**

Experimental procedure for capturing sulfur in coal using dolomite. Dolomite sample was taken in different ratio with respect to coal such as 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7 and divided dolomite in such a way that three parts of dolomite was mixed with coal and remaining one part was smoothly spread on the layer.

Every time fresh mixture of dolomite and coal was made for each testing. The 1-gram sample of coal was taken and 3 parts of dolomite mixed well in crucible. Mixture was covered with 1 part remaining of dolomite. Crucible was put into cold furnace and raised the temperature gradually up to 800 ± 25°C the above temperature was maintained for one and half to 2 hours and then crucible was taken out from the furnace and checked by stirring the sample. If the black particles were not found, indicated that combustion has been completed. The crucible was cooled in the desiccator and emptied in the 250 ml beaker and digested with 100 ml distilled water.

Results and Discussion

The moisture content found in Pakistani local coal whose percentages may vary from one sample to another. While TABLE 2 depicts the volatile content present in coal which is 30%, it shows it is used as kiln coal but not for coke production purposes. In TABLE 3 there is a measured value of ash content which is approximately 29 in average. While in TABLE 4 fixed carbon is measured by adding Moisture+VM+ASH (TABLE 5) [19].

TABLE 2. **Moisture content in coal sample.**

Sample #	**Weight of sample (g)**	**Weight loss (g)**	**Moisture (%age)**
01	1.00	0.031	3.1
02	1.00	0.0298	2.98
03	1.00	0.03	3.0
Mean percentage of moisture		3	

TABLE 3. **Volatile matter content in coal sample.**

Sample #	**Weight of sample (g)**	**Weight loss (g)**	**Volatile matter (%age)**
01	1.00	0.30	30
02	1.00	0.32	32
03	1.00	0.29	29
Mean percentage of volatile matter		30	

TABLE 4. **Ash content in coal sample.**

Sample #	**Weight of sample (g)**	**Weight loss (g)**	**Ash (%age)**
01	1.00	0.28	28
02	1.00	0.29	29
03	1.00	0.30	30
Mean percentage of ash		29	

TABLE 5. **Fixed Carbon content in coal sample.**

Sample #	**Fixed carbon (%)**
01	39
02	37
03	38
Mean percentage of fixed carbon	38

TABLE 6. **GCV in coal sample.**

Sample #	**Gross calorific value Kcal/Kg (%age)**
01	4800
02	4900
03	5000
Mean of GCV	4900

TABLE 7. **Sulfur evaluation and its adsorption/absorption.**

Sample #	**Fixed carbon (%)**
01	5.45
02	5.38
03	5.40
Mean value	5.4

TABLE 8. **Determination of %age sulfur content of Makarwal coal using calcined and non-calcined dolomites by using Eschka mixture method.**

Ratio	**DA**	**DCA**	**DK**	**DCK**	**DM**	**DCM**
1:1	1.92	2.61	2.88	2.47	1.52	2.47
1:2	2.19	3.02	3.02	3.84	2.47	2.61
1:3	2.33	3.29	3.57	3.98	2.74	3.02
1:4	2.47	3.43	3.7	4.10	3.02	3.23
1:5	2.60	3.57	3.84	4.25	3.30	3.43
1:6	2.88	3.7	3.95	4.37	3.57	3.5
1:7	3.02	4.02	4.05	4.5	3.98	4.25

TABLE 9. **Calculation of sulfur capture efficiency of calcined and non-calcined dolomites by evaluating information available.**

Ratio	**DA**	**DCA**	**DK**	**DCK**	**DM**	**DCM**
1:1	35.56	48.33	53.33	45.74	28.15	45.74
1:2	40.56	55.93	55.93	71.11	45.74	48.33
1:3	43.15	60.93	66.11	73.70	50.74	55.93
1:4	45.74	63.52	68.52	75.93	55.93	59.81
1:5	48.15	66.11	71.11	78.70	61.11	63.52
1:6	53.33	68.52	73.15	80.93	66.11	64.81
1:7	55.93	74.44	75.00	83.33	73.70	78.70

The results of the capture of sulfur from coal using dolomite of Abbottabad, Mianwali, and Kalarkahar. It has been found that the capture of Sulfur increased with the increasing in ratio of dolomite in coal (TABLES 6-9).

The capture of sulfur was higher in dolomite Kalarkahar, compared to dolomite Mianwali and Abbottabad. Maximum of sulfur capture using non calcined dolomite was observed at 1:7 where 75%, 73.70% and 55.93% was removed by DK, DM and DA dolomite respectively (FIG.5) [20].

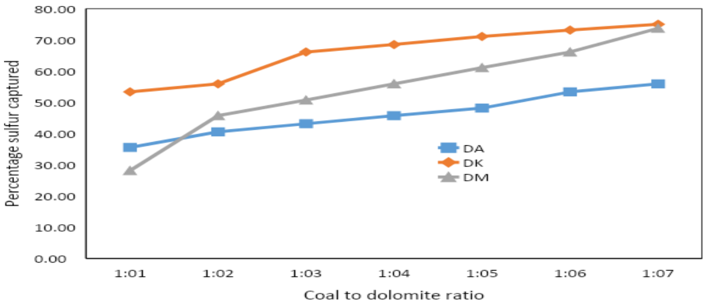

FIG.5. **%age capture of non-calcined dolomite of Abbottabad, Kalarkahar and Mianwali.**

The result of the capture of sulfur from coal using calcined dolomites of Abbottabad, Mianwali, and Kalarkahar regions. It has been found that the capture of Sulfur increased with the increase in ratio of dolomite in coal (FIG.6).

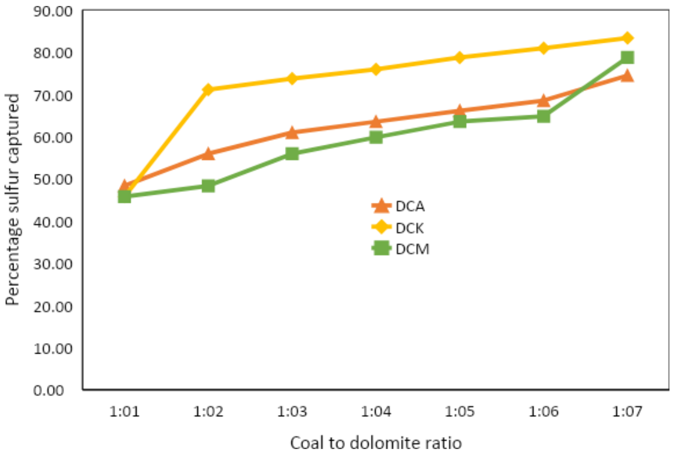

FIG.6. **Efficiency of calcined dolomite of Abbottabad, Kalarkahar and Mianwali.**

Moreover, calcined dolomites removed more sulfur as compared to its non-calcined type. In case of calcined dolomite, maximum of 83%, 78% and 74%. It was noted that the performance of dolomites in sulfur capture was significant compared to standard Eschka mixture (Na_2CO_3/MgO) combination. From the above discussion Kalarkahar dolomite may be used.

It is evident that calcined dolomites can work efficiently as compared to non-calcined dolomites, the reason is that when dolomite is calcined at 900°C, CO_2 eliminated from the surfaces of dolomites. Hence, the pore size of calcined dolomites increases. So due to large pore volume, calcined dolomite can capture maximum SO_2 that emitted from coal combustion [21].

During the combustion various reactions occur between CaO and sulfur present in coal to form CaS, when finally ground coal and CaO is heated at 820°C. Calcined lime and calcined dolomite found to be more effective than non-calcined that varies between ratios from 1 to 7. The degree of conversion of pyrite to calcium sulfide weight ratio of 7 has been found more effective at temperature of 820°C and time duration is 2 hours. It has been found that total sulfur that found in coal has been decreased by using calcined lime and dolomite as sorbent and sulfur converted to CaS and sulfur capture increases by increasing amount of sorbent.

Sorbent particle size also effect on sulfur capture from coal. Fabrizio Scala studied that with reduction in particle size of sorbent, efficiency of sulfur capturing increases. This is consistent with the concept observed by Ray. in 1987 that attired fines size is related to a natural grain size of the material. Results show that most separated material size is below 0.15 mm. Separated fines collected during sulfating phenomenon appear to be slightly coarser than those elutriated during calcination.

In dolomite only CaO, and not MgO, took part in the binding of CO_2 then, the higher the mole ratio of MgO/CaO in the sample and the lower the specific surface area of the sample are, the faster the binding of CO_2 stopped resulting in the formation of $CaCO_3$ shell on the surface of the particles, hindering the later diffusion of CO_2 into the grains of sample [22].

Dolomite calcined at 900°C shows normally the highest reactivity when compared with non-calcined dolomite. A large number of pores exist on the surface of the particle. Calcined dolomite has high reactivity and is very porous. If dolomite calcined at higher temperature, then it can cause loss of the reactivity. It is due to the grain growth and densification of dolomite structure. A lot of pores, which are created due to thermal decomposition of dolomite, gets closed. If dolomite calcined at relatively low temperature, then there are less pores on the surface of dolomite particle because of incomplete and partial thermal decomposition of dolomite.

The efficiency of dolomite Abbottabad is shown. It be seen that non calcined dolomite can capture the sulfur upto 50%, while when the same dolomite is used on calcination its efficiency increased due to increase in pore size distribution and it can capture maximum SO_2 and its efficiency is increases up to 80% (FIG.7).

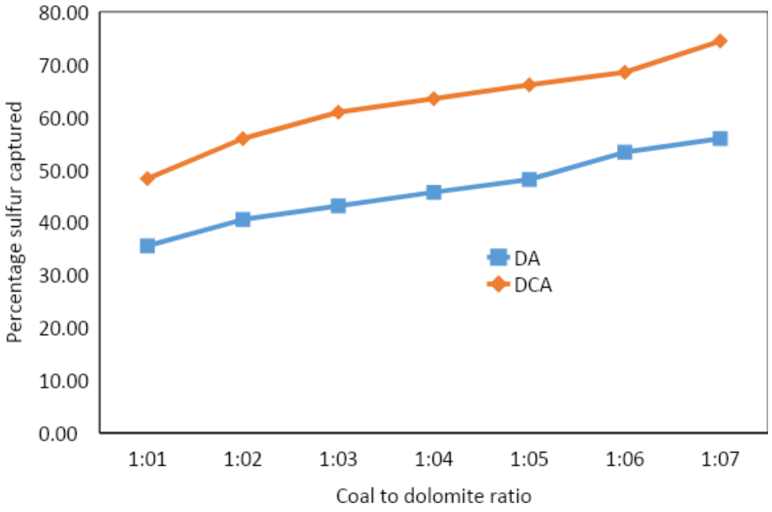

FIG.7. **Efficiency of non-calcined and calcined dolomite Abbottabad.**

Different points are shown which shows that the sulfur capturing behavior of dolomite Kalarkahar. Non-calcined dolomite at 1:7 gives the maximum result and capture the sulfur up to 70%, whereas due to increases in pore size, it can capture up to 80% sulfur (FIG.8).

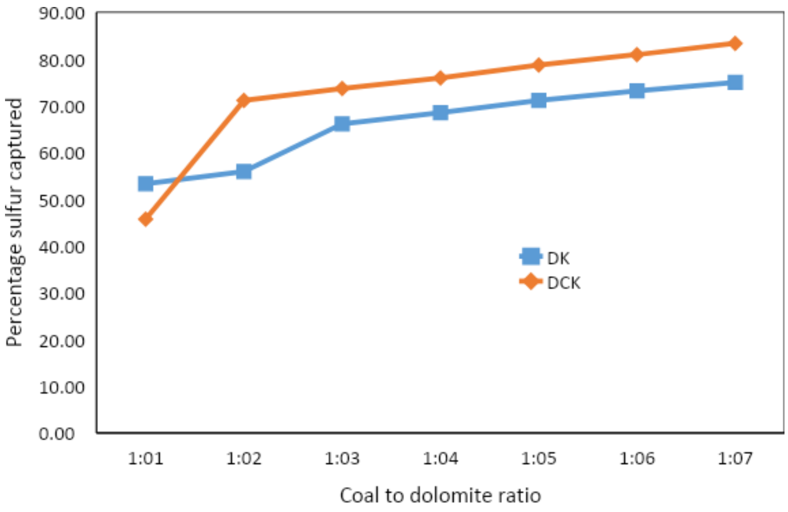

FIG.8. **Efficiency of non-calcined and calcined dolomite Kalarkahar**.

That Mianwali non-calcined dolomite can capture the sulfur up to 70% while calcined Mianwali dolomite can capture up to 78% of sulfur from coal, at coal to dolomite ratio of 1:7.

It was noticed that, best result was obtained at 1:7 i.e. (coal: dolomite). Calcined dolomites are more effective among simple dolomites, as shown in TABLE 10. Dolomite of different regions giving different results. It is due to difference in chemical composition of dolomites Ca/Mg ratio. It depends upon the percentage purity of dolomite with respect Ca/Mg.CO_3. More is the percentage of the CaO more is the capture capability of sulfur of dolomite. It is noticed that among other dolomites Kalarkahar is giving best results due to percentage purity result that will be shown in FIG.9 and their efficiency with regard to Eschka mixture is shown in FIG.10 [23].

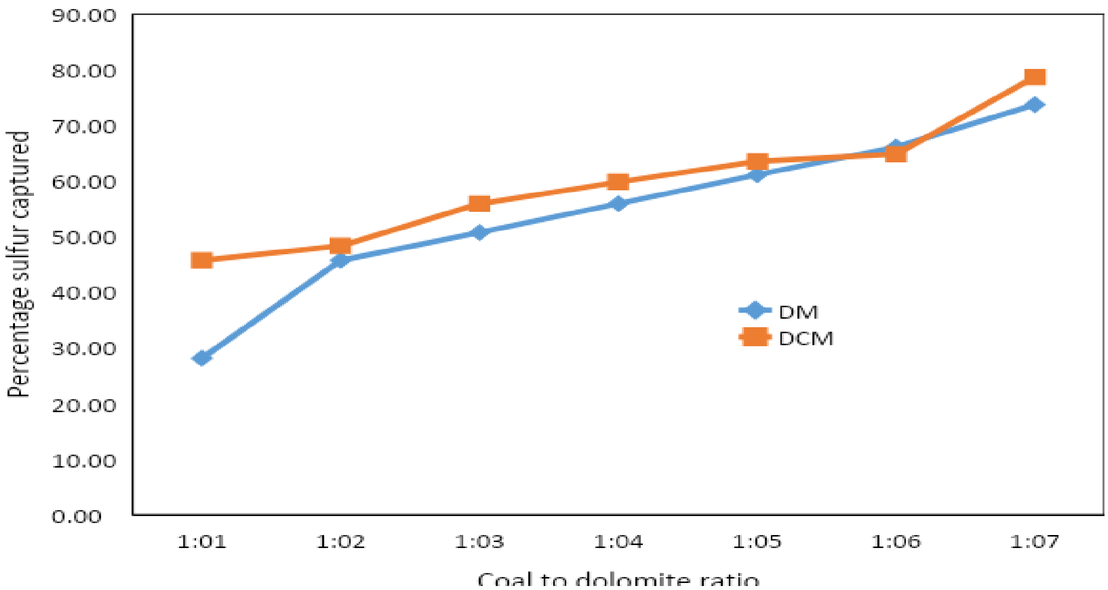

FIG.9. **Efficiency of dolomite non-calcined and calcined Mianwali.**

TABLE 10. **Determination of %age sulfur content of Makarwal coal using calcined and non-calcined calcium carbonate by using Eschka mixture method.**

Ratio	$CaCO_3$	CaO	% sulfur capture	
			$CaCO_3$	CaO
01:01	2.61	2.7	48	50
01:02	2.7	2.84	50	53
01:03	3.15	3.03	58	56
01:04	3.43	3.43	64	64
01:05	3.69	3.76	68	70
01:06	3.96	4.1	73	76
01:07	4.03	4.25	75	79

It is noticed that $CaCO_3$ as well as CaO can capture sulfur significantly. The reactivity of calcined limestone is more efficient than non-calcined. It was found that the sulfur capturing efficiency of non-calcined calcium carbonate at coal to dolomite ratio of 1:7 was 75%. By using calcined calcium carbonate at coal to dolomite ratio of 1:7, the sulfur capturing efficiency was 79%.

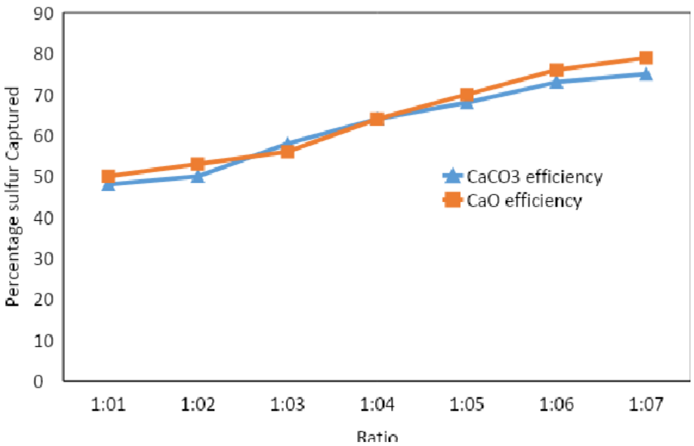

FIG.10. **Efficiency of calcium carbonate and calcium oxide.**

Conclusion

Effectiveness of calcium carbonate on sulfur capture if calcium carbonate calcined at 900°C, it shows normally the highest reactivity as compared to non-calcined calcium carbonate. A large number of pores exist on the surface of the particle. Calcined calcium carbonate has high reactivity and is very porous as compared to non-calcined calcium carbonate. If calcium carbonate calcined at higher temperature, then it can cause loss of the reactivity. It is due to the grain growth and densification of lime structure. A lot of pores, which are created due to thermal decomposition of lime stone, gets closed. If calcium carbonate calcined at relatively low temperature, then there are less pores on the surface of lime particle because of incomplete and partial thermal decomposition of limestone.

It has been noticed that dolomite can capture the sulfur more efficiently instead of limestone. While, calcined dolomite work more competently as compared to the non-calcined dolomite. This is due to the pore size distribution that would be increased when it is subjected to high temperature and CO_2 is evolved. So the reactivity of calcined dolomite for capturing the sulfur is improved in this way.

It is also noticed that dolomite is more effective on low rank coal. It can remove inorganic and organic sulfur very easily as it captures sulfur in the form of SO_2. Removal of sulfur content in coal will affect its calorific value as with ignition sulfur also produces heat but with removal of sulfur calorific value reduced. Thus quality of coal can be improved with respect to its utilization such as ignition properties in power sector.

References

1. Braganca SR, Castellan JL. FBC desulfurization process using coal with low sulfur content, high oxidizing conditions and metamorphic limestones. Brazilian J Chem Engineer. 2009;26(2):375-383.
2. Cheng J, Liu J, Cen K, et al. Sulfur removal at high temperature during coal combustion in furnaces: A review. Progress Energy Combust Sci. 2003;29(5):381-405.
3. Cheng G, Zhang C. Desulfurization and denitrification technologies of coal-fired flue gas. Polish J Environmental Stud. 2018;27(2):481-489.
4. Cheng X, Bi XT. A review of recent advances in selective catalytic NOx reduction reactor technologies. Particuol. 2014;16:1-18.
5. Chelgani SC, Hower JC, Jorjani E, et al. Prediction of coal grindability based on petrography, proximate and ultimate analysis using multiple regression and artificial neural network models. Fuel Process Technol. 2008;89(1):13-20.
6. Deelman J. Low-temperature formation of dolomite and magnesite. Compact Disc Publicat. 2003.
7. Dweck J, Buchler PM, Coelho ACV, et al. Hydration of a portland cement blended with calcium carbonate. Thermochimica Acta, 2000;346(1): 05-113.
8. Dyrkacz GR, Horwitz EP. Separation of coal macerals. Fuel. 1982;61(1):3-12.
9. Scott AC. Coal petrology and the origin of coal macerals: A way ahead? Int J Coal Geol. 2002;50(1-4):119-134.
10. Kalyoncu RS, Olson DW. Coal combustion products. 2001.
11. Kessel I, O’Connor JT. Lead in food, in getting the lead out. Springer 1997;135-140.
12. Kaljuvee T, Trikkel A, Kuusik R. Decarbonization of natural lime-containing materials and reactivity of calcined products towards SO_2 and CO_2. J Thermal Analysis Calorimet. 2001;64(3):1229-1240.

13. Morse JW, Arvidson RS, Luttge A. Calcium carbonate formation and dissolution. Chem Rev. 2007;107(2):342-381.

14. Pohwat PW. connoisseur's choice: siderite siete suyos mine, atocha-quechisla district sud chichas province, potosí department, bolivia. Rock Mineral. 2012;87(3):246-257.

15. Rohleder J, Kroker E. Calcium carbonate: From the cretaceous period into the 21st century. Birkhauser. 2012.

16. Santra M, Singh RS, Bagchi B. Nucleation of a stable solid from melt in the presence of multiple metastable intermediate phases: Wetting, Ostwald’s step rule, and vanishing polymorphs. J Phy Chem B. 2013;117(42):13154-13163.

17. Scala F, Salatino P. Dolomite attrition during fluidized-bed calcination and sulfation. Combustion Sci Technol. 2003;175(12): 2201-2216.

18. Smith KL, Smooth LD, Fletcher TH, et al. The structure and reaction processes of coal. Springer Sci. 2013.

19. Speight JG. The chemistry and technology of coal. Chem Indust. 2012.

20. Siagi Z, Mbarawa M, Mohamed AR, et al. The effects of limestone type on the sulphur capture of slaked lime. Fuel. 2007;86(17): 2660-2666.

21. Wang W, Ramkumar S, Li S, et al. Subpilot demonstration of the Carbonation-Calcination Reaction (CCR) process: High-temperature CO_2 and sulfur capture from coal-fired power plants. Ind Engineer Chem Res. 2010. 49(11): 5094-5101.

22. Han DH, H.Y. Sohn HY. Calcined calcium magnesium acetate as a superior SO_2 sorbent: I Thermal decomposition. AIChE J. 2002;48(12):2971-2977.

23. Xu X, Chen C, Qi H, et al. Development of coal combustion pollution control for SO_2 and NOx in China. Fuel Process Technol. 2000;62(2):153-160.