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Research Article

Electro Kinetic Potential Technique for Ore Beneficiation of $CaCO_3$

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Abstract: Electro Kinetic Potential technique also called zeta potential technique is one of good methods for ore beneficiation. In this method, the required ore material is kept at Electro Kinetic potentials by adding respective chemical to maintain pH. The CaCO3 is kept at electro kinetic potential of pH 9.5 by adding NaOH, which makes the other impurities to attain ionization. This solution is passed through anion and cation resins. The metal impurities of pH less than 9.5 will be trapped in the resins by ion exchange principle and the neutral CaCO3 will be passed along with the solution. Dewatering is done by membrane filtering and pressing techniques. The saturated resin beds can be reactivated and reused.

Keywords: Calcium carbonate, Vempalli lime stone, calcite, aragonite and vaterite

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INTRODUCTION

Calcium carbonate exists in three crystal structures viz., calcite, aragonite and vaterite. Calcite is most widely occurring form of the mineral and predominantly used in sealants and adhesive applications. Chemical grade Calcium carbonate has extensive applications in various industries such as cement, plastic, steel, paper, food and pharma industries[1-3]. The Cuddapah basin contain a thick pile of Lime stone deposits in three stages, Vempalli limestone stone at the bottom of the basin and Narji limestone in the middle and

Koilakuntla limestone in the top of the Basin. Vempalli limestone belongs to lower Cuddapahs and both Narji limestone, Koilakuntla limestone belong to the Kurnool subbasin[4]. The limestone occurring in the Cuddapah Basin contains certain impurities like Si, Al, Fe, Mg which are in different forms. In the present study, the impurities will be removed to get chemical grade $CaCO_3$ named as precipitated Calcium carbonate/synthetic calcium carbonate/nano calcium carbonate by Electro Kinetic Potential technique otherwise known as zeta potential. The fluidized ore maintained at pH of 9.5 to attain electro kinetic potential or zeta potential for $CaCO_3$ by adding NaOH where the gangue minerals will be respectively ionized. The $CaCO_3$ will be neutral during further processing. This fluidized ore when passed through respectively ionized resin beds and then through mixed bed traces impurities like Si, Al, Fe, Mg etc., will be removed resulting high grade $CaCO_3$.

METHODOLOGY

The raw material is kept sufficient closed storage hoppers and crushed to pebble size by jaw crushers. Crushed limestone is then powdered to less than 10µm in differencial pressure crushers upto a hardness of 4 of the Moh's scale. Where the undesired impurities having Mohs scale hardness more than 4, **(Table 1)** will not be crushed and can be removed easily. The powdered ore material passed through the magnetic separator where majority of magnetic material will be collected[5]

Table- 1 Hardness of contents of ore body

S.No.	Name of the material	Hardness
1	$CaCO_3$	3
2	Mg	2
3	Fe^{2+}	6
4	Fe^{3+}	6
5	Si	7
6	Al	3

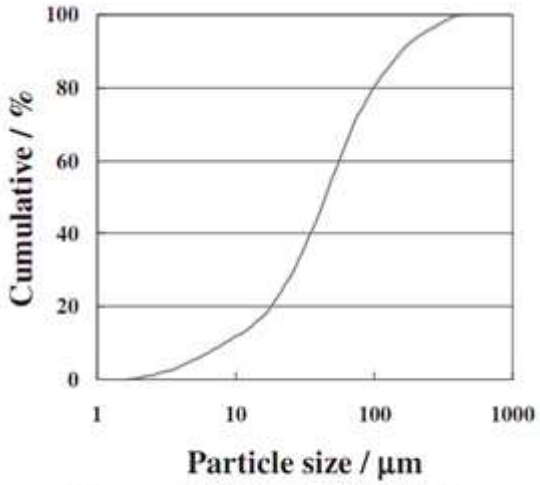

Figure 1 Cumulative undesired impurities collected from the dissolved limestone

Then the limestone powder lifted to preheat with the help of elevator continuously. In the pre-heater, the ore pre-heated with the help of air coming from the kiln. Calcinations of the material done in the keln at a temperature of 1010^0C. During the process CO_2 liberated as shown in the reaction

$$CaCO_3 \longrightarrow CaO + CO_2.$$

The calcinated ore collected and cooled with air. The resultant hot air used for heat recovery system. The lime mixed with water to produce calcium hydroxide[6] as follows

$$CaO + H_2O \longrightarrow Ca(OH)_2.$$

The hydrated lime [Ca $(OH)_2$] is reacts with CO_2 to give rise to a good quality of precipitated calcium carbonate (PCC).

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

The entire process shown in **Fig.2** finally the any remaining impurities and grit separated from the PCC pulp by the process of electro kinetic potential/zeta potential technique.

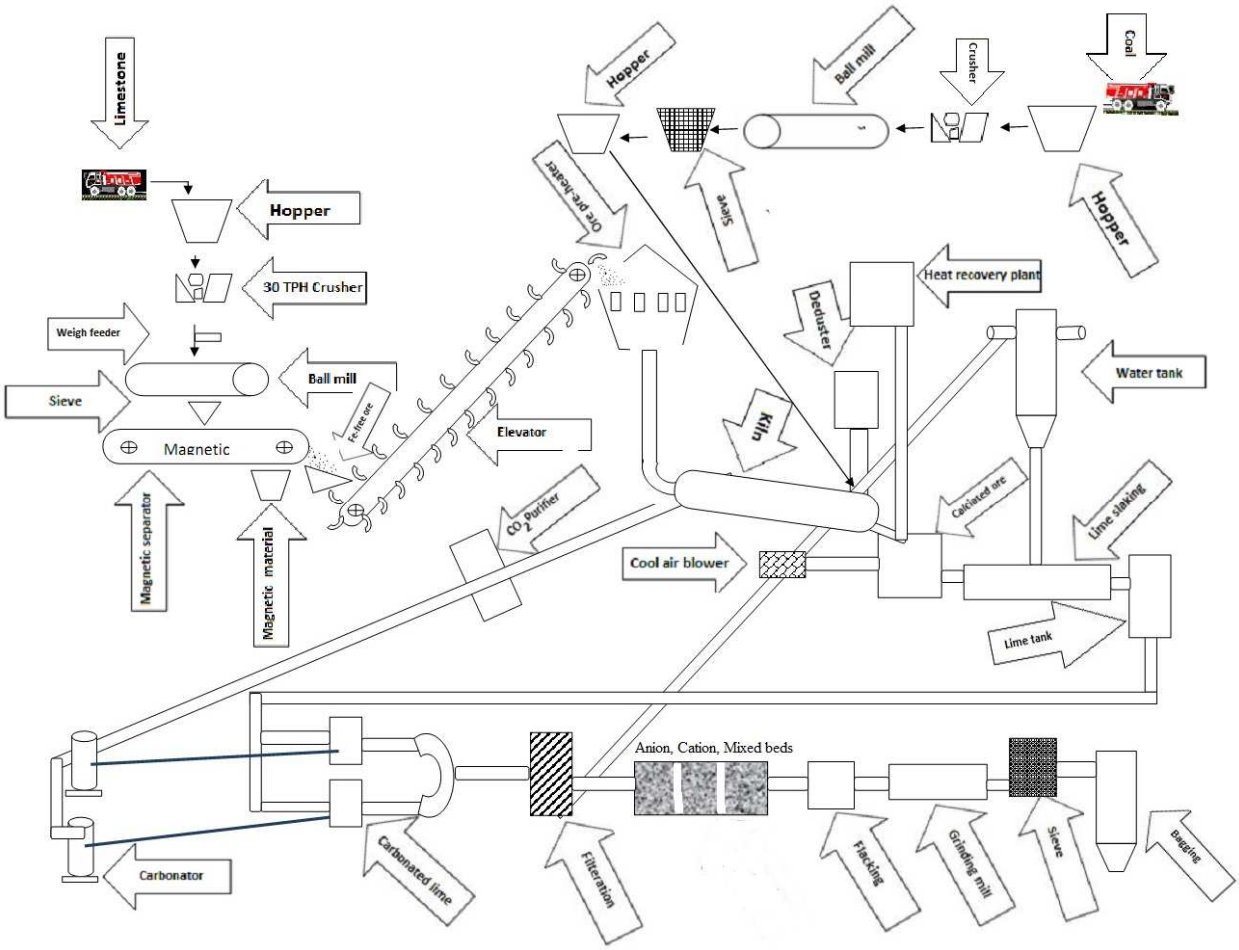

Fig. 2 Ore beneficiation process

Electro Kinetic Potential or Zeta potential is the potential difference between the dispersion medium and the stationary layer of fluid attached to the dispersed particles. The significance of zeta potential is that its value can be related to the stability of colloidal dispersions. The zeta potential indicates the degree of repulsion between adjacent, similarly charged particles in dispersion[7].

Table- 2 Zeta potentials of contents of ore body[8]

S.No.	Name of the material	Zeta potentials
1	$CaCO_3$	pH 9.5
2	Mg	pH 12-13
3	Fe^{2+}	pH 4.8-6.7
4	Fe^{3+}	pH 6
5	Si	pH 2-3
6	Al	pH 7.8-8.1

The pH of the fluidized ore is one of the most important factors that affect its zeta potential **(Table 2).** A particle in suspension with a negative zeta potential when more alkali added to this suspension the particles tend to acquire more negative charge[9]. If acid added to the suspension then a point will be reached where the charge will be neutralized. Further addition of acid will causes a buildup positive charge. Therefore, zeta potential versus pH curve will be positive at low pH and negative at high pH. There may be a point where the plot passes through zero zeta potential. This point is called isoelectric point at which the system is lease is lease stable **(Fig.3).** The isoelectric point is different for different ore minerals[10].

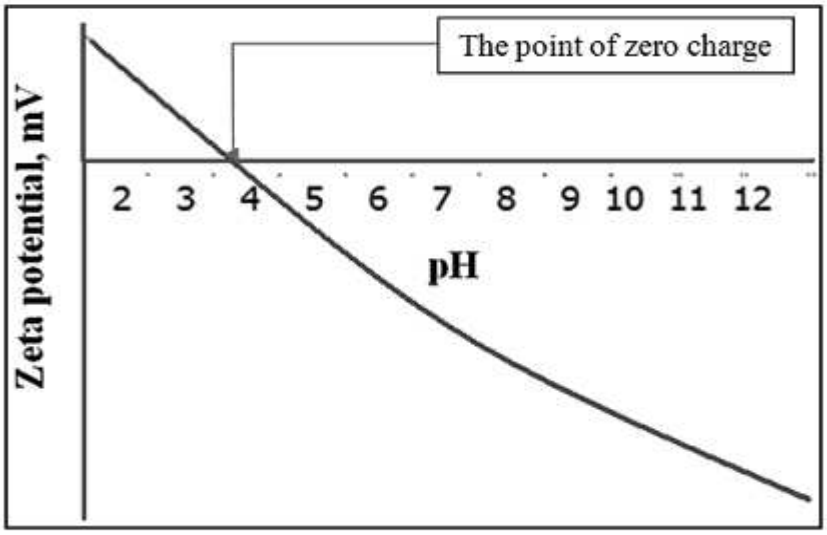

Figure 3 . Relation of zeta potential on pH .
Ref: Sivarote Siriluck et.al., 2011

RESULTS AND DISCUSSION

The ore crushed by differential pressure crushers up to a hardness of 4 of the Moh's scale. The magnetic separator removed the magnetic minerals. The ore powder is fluidized and passed through nano filters resulting removal of 90% of gangue minerals having higher hardness of more than four and higher particle such as Fe, Si, Mg. The resulting ore powder passed through three stages of calcination, hydration and

carbonation. Electrokinetic potential or zeta potential is the potential difference between the dispersion medium and the stationary layer of the fluid attached to the dispersed particle. The $CaCO_3$ solution is mixed with Sodium Hydroxide (NaOH) to attain zeta potential to $CaCO_3$. The zeta potential of gangue minerals in the solution are given in the **Table 2,** viz., Hematite is 4.8-6.7, Magnetite is 6, Silica is 1.7-3.5, Magnesia (MgO) 12-13 and that of Alumina 7.9-8.1. When NaOH added to aqueous solution the $CaCO_3$ attain isoelectric point and the gangue minerals will get respective polarity and thus potential difference. This solution passed through anion, cation and mixed resin bed. At this stage the gangue mineral having pH less than 4, i.e., Silica will be removed at anion bed and remaining gangue minerals, Aluminium, Hematite, Magnetite, Magnesium which are having pH above 4 are separated at cation bed[10]. This property may be named as reverse ionization technique. During the separation process following reactions will takes place.

Reaction in anion bed: $RSO_3^- H^+ + M^+ \rightarrow RSO_3\text{-}M^+ + H^+$

Reaction in cation bed: $R^+ OH^- + X^- \rightarrow R^+X^- + OH^-$

Any leftout charged minerals would be separated at mixed bed give rise to high-grade calcium carbonate.

CONCLUSIONS

The low-grade calcium carbonate containing impurities at different levels can be beneficiated to get very high grade Calcium Carbonate by applying the electro kinetic potential technique. The low-grade ore material taken from the mine is powdered and passed through various stages, initially through the magnetic separator and magnetic minerals will be separated. Then it heated to a temperature of 1400^0C for calcination. The calcinated ore is hydrated and carbonation done in the further stage. During the final stage of ore beneficiation, the ore mineral is subjected to electro kinetic potential/zeta potential technique by adding NaOH solution till it attain a pH of 9.5 which is the zeta potential of $CaCO_3$. At this pH the gangue having zeta potential other 9.5 will get polarity. Subsequently they will be removed by anion cation and mixed bed resulting very high grade $CaCO_3$.

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