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Mechanised Production of Dry Hydrated Lime

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Abstract

Lime in its various forms has al ways occupied an important role in construction. Most of the uses to which lime is put are such, which require that the quicklime should first be converted into the form of hydrated lime. Hydrated line can be manufactured as dry power by treatment of quicklime with such quantity of water which is enough to satisfy its chemical affinity.

A machine for hydration of lime has been designed, fabricated at the Central Building Research Institute for the continuous prpearation of dry hydrated lime at atmospreric pressure. Extensive field trials with this machine has been done and the perfomace of this machine was found very satisfactory. Design aspects of this machine andthe other related Equipments required, with the possible lay-outs for setting up a lime complex mainly for the production of commercial dry hydrated lime have been discussed in this paper.

Lime obtained direct from the kiln after calcination known as quicklime and consists essentially of oxides of calcium and varying amount of magnesium together with smaller quantities of silica, Alumina, iron oxide and numerous other impurities.

Most of the uses to which lime is put to are such that whch requires that quicklime should first be converted into the form of hydrated lime which essentially consists of calcium hydroxides along with the associated substance that are derived from the impurities present in the limestone sample.

Hydration of quicklime can be achieved by one of the three ways :—

(a) The direct and careful addition of water to the quicklime.

(b) The addition of steam to the quicklime.

(c) The exposure of the quicklime to air to allow it to be treated by the moisture of the air.

Of the above three ways, the best one is to allow the water to react directly with the quicklime. Use of steam would be uneconomical and exposure to air to be treated by moisture is very slow process. Moreover, carbon di-oxide present in the air turns part of the lime into Carbonate during exposure.

Although the conversion of quicklime into hydrated lime appears to be a very simple process but the reaction is governed by numerous factors which, affects the properties of final product. It is, therefore, desirable that manufacturing of hydrated lime should be carried out in a factory under controlled condition.

Lime vary largely in their hydrating properties. The choice of a hydrator has to be based only upon a close study of the hydrating properties of lime.

There are two main important properties of the hydrated lime which must be secured in the product and the design of the machine should be suited to obtain this. Properties are (i) Chemical Reactivity (ii) Plasticity of the hydrate.

Both these properties depend upon the nature of the particles formed during hydrating. It is well known that a lime putty made by slaking lime in Excess of Water is more plastic and reactive than hydrate produced as a dry powder.

Therefore, to make more plastic and chemically reactive hydrated lime, it is necessary to approach as much as possible to the conditions which prevail in slaking to a putty. This is secured when the design and operation of the hydrator is such that the maximum possible part of the reaction takes place in the presence of liquid water.

Types of the lime Hydration

(a) Hydration at atmospheric pressure.

(b) Pressure Hydration.

Hydrating machines working at atmospheric pressure are suitable for dry hydrating (i) High calcium quicklime containing not more than 5% MgO (ii) soft burned dolomitic lime.

Capacities of hydrators may vary from 1 to 15 ton

/hr, but it is better to use two or three seperate small to medium sized hydrator for different quality products. For hydrating machines from 1000 to 18,000 Kg/hr. Capacities, power requirement ranges from 2 to 30 KW.

Pressure hydrating is suitable for hydrating dolomitic lime. Pressure may range from 2 to 7 Kg/cm² depending on the quality of the limestone. Distinguishing feature from atmospheric hydration is that an auto-clave cylinder is used as a hydration chamber into which lime and water are introduced at a Constant Weight ratio or Volumetric proportional. In the pressure hydration plants, hydration occurs in a vaporous atmosphere and the time of hydration is shortened by the highest pressure and temperature.

Hydrati on of Hydraulic Lime

Hydraulic limes are so easily overburnt neith consequent slow rate of reaction, that their complete hydration may offer difficulties. When hydraulic limes are hydrated to a dry power, as that operation is carried out properly, the hydraulic set is fully retained.

The semi hydraulic type, if not overburnt can readily be treated in efficient hydrating plant operating at atmospheric pressure, but eminently hydraulic limes unless burnt at closely controlled low temp. may yield unsound hydration under pressur- ensures their complete hydration with the retension of hydraulic set. It has been a custom to grind the hydraulic limes to a fine powder thus increasing their rate of hydration.

Water Conntent

Assuming complete hydration and 100% pure quicklime, the water of hydration is 24.3% for high calcium and 27.2% for true dolomite lime. The balance of 75.7% and 72.8% for high calcium and dolomitic respectively is the lime solids content. This clearly shows that there is an increase in weight of the original quicklime to at least the extent of the water of hydration.

Practically an excess of moisture over the theoretical amount is essential to achieve complete hydration since some water will be lost through evaporation by the heat of hydration and invariably there is at least a fractional per cent of absorbed free water that is not chemically combined but that envelops the hydrate particle like a film. This later moisture cannot be removed by mechanical means.

Consequently, if only the theoretical amount of water is added, the lime will be incompletely hydrated and unstable oxides will still be present with the hydroxides. Secondly, the excess heat which is evolved during the hydration would raise the temprature of lime beyond 100°C which is not desirable. Practically the amount of water required for complete hydration for a high calcium quicklime is about 60% of the lime solid's weight.

Hydrated Lime Forms

Hydrated lime can be produced as a dry hydrate, putty, slurry, Milk of lime or lime water. The main distingu is hing characterstic of which is the amount of excess water they contain.

Among various forms of hydrated lime, dry hydrate is the most concentrated form of hydrate which can be produced commercially. Some of the advantages of dry hydrate over the other forms of hydrated lime are as follows :—

(a) Dry hydrated lime is a stable material, easy to handle and transport.

(b) It possesses definite uniform properties and can be stored for an indefinite period.

(c) Dry hydrate can be readily mixed with water of reduced to any desired it can also be incorporated in motars and plaster in exact proprtions.

(d) Dry hydrated lime is a more profitable product to manufacture.

About 125 tons of hydrate are made from 100 tons of quicklime due to difference in the specific gravity. Also hydrate is generally sold at about 15% higher price per ton on a comparable bulk basis.

Rate of Hycration

Reaction between lime and water depends upon the concentration and temp. Of the reactant, the properties of the quicklime. Even in the lime of same purity, the rate of hydration can differ very widely. It is therefore advonted that the rate of hydration and the optimum hydration condition must be determined empirically and individually in each case. The rate of reaction can be markedly affected by even slight deviation in the condition of hydration.

Factors influencing rate of reaction are :—

(i) *Purity of lime* :—High chemical purity abets rapid hydration. Impurities decrease the rate of hydration.

(ii) *Porosity of lime* :—Commercial lime ranges around 60% porosity. Rate of reaction would increase with porosity.

(iii) *MgO content* :—Increasing increments of MgO have a retarding effect on the rate of reaction.

(iv) *Temperature* :—The rate accelerates with increasing temp of both reactants particularly water.

(v) *Amount of Water* :—Increasing the amount of water retards the rate of hydration.

(vi) *Agitation* :—Agitation of lime and water increases the rate of hydration.

(vii) *Size of the quicklime* :—Small size (ground quicklime) is more rapid in hydrating than lump or pebble.

(viii) *Air slaked* :—A quicklime partially air slaked hydrates sluggishly.

Commercial Dry Hydration

A vast majority of lime consumers does not purchase quicklime and slake it for their own consumption. Indeed they can not possibly justify the capital cost of the slaking equipments and the inevitable problems attendant to another processing step that slaking entails. Their lime requirements are simply too small, so they prefer to purchase commercial hydrated lime. Only large consumers slake their own. Commercial hydrate is a dry powder representing the most concentrated form of hydrate that exists. The purchase of hydrate in dilute forms such as putty would be uneconomical because of the cost of transporting so much free water, as well as the cost of the suitable containers.

It is obvious that dry hydration is more complicated than wet slaking since the final hydrate must be dry so that it is easily packed in bags. All high quality commercial hydrate must be produced entirely in closed-circuit systems in such a way that the carbon di-oxide may be excluded as far as possible and may not cause any contamination.

The process of hydration can be carried out in batches or in a continuous system. But continuous systems have replaced batch system because of greater capacity, automation and superior dust control.

As the nature of the limestone and the lime burning plant utilised for the calcination of limestone, influence the nature and the quality of the lime, the process of hydration has to be adopted to obtain the required quality of hydration. Most imporant factors that should be kept in view before selecting the type of Equipment and hydration plant layout are :—

(1) Chemical purity of the quicklime.
(2) Porosity and slaking rate of the quicklime.
(4) Size of the quicklime to be fed into the hydrating machine.
(5) Desired particle size of the resulting hydrate.

Equipments generally required in commercial hydration plant, utilising atmospheric pressure are comprised of :—

Crushing of the Quicklime

The quicklime received from the kiln is usually ni the form of big lumps. It is vary necessary to reduce the quicklime to make the hydration process more efficient and for uniform mixing of the two reactants.

Big lumps of the lime can be broken efficiently to 1 cm. by means of a hammer-mill. This is essentially a high speed machine with some form of slugger hammer attached to the rotor to shatter and grind the material against a bar screen cage. The spacing of the bars determines the size of the product specially the maximum lump.

Other mechanical equipments which can be used for crushing of quicklime are Impact breaker, small gyratory crusher and cone mill.

Conveyor

Quicklime about 1 cm. size from the crushing Equipment is conveyed to the lime hydrating machine. Bucket elevator can be used for vertical transport of quicklime into the hopper attached with a feeder of the lime hydrating machine. Two way chute can be provided at the discharge end of the bucket elevator, so that two hydrating machines can be fed a single bucket elevator. Of the different types of bucket elevators, the most suitable for feeding of quicklime is a centrifugal discharge type high speed bucket elevators.

Lime Hydrating Machine

A hydrating machine is the keystone of a hydration plant. In this machine, reaction is carried out in horizontal troughs or chambers which are equipped with an efficient agitation paddles producing an intimate mix of lime and water and for impelling the mixture through, like a screw conveyor.

There are three troughs in the machine which are known as :— (a) Pre-mixing chamber (b) Main hydrating chamber (c) Finishing chamber.

Pre-mixer serves for feeding and intermixing the two component (Quicklime and water) before entering the main hydrating chamber. The mixture of lime and water from the pre-mixer contain water in much excess than required for complete hydration. The heat of hydration inside the main hydrating chamber evaporates the excess water and the hydrate is dicharged from the machine as dry powder from the outlet of the finishing chamber. In the third finishing chamber hthe ydrate is thoroughly loosened up by the stirring paddles. It disperses thereby the last remnant of surplus moisture and makes it possible for the specifically heavy grit and impurities to settle down at the bottom of the trough, which can then be continuously discharged whilst the lighter hydrate flow oever a weir plate which can be adjusted in height, weir plates are also provided in the main hydrating chamber at the discharge side. By adjusting the height of the weir plate, contact period available for the reaction can be varied.

Fig. 1
Lime Hydrating Machine (Capacity 10 T Shift)

All the three slaking chambers are positioned one above the other. The space in each and the holding capacity is adopted for each chamber in proportion to the increase in volume of the hydrate during the hydrating process, as the vlume increases approximately by 225% of the initial volume.

All the three slaking troughs are mounted on common, rigid side shields with screwed brackets for holding the self aligning ball bearings. The three slaking troughs are completely dust proof due to sheet metal liners and the stuffing boxes provided at the each end of the shaft. There are also inspection and clearing doors for each trough.

The steam generated during the process of hydration is not allowed to escape to the atmosphere but is utilised in preheating the water that affects hydration. Wet dust collector is provided with the lime hydrating machine to settle the lime dust with the feed water. Hot lime milk this obtained is passed to the premixer through the spraying jets.

It is genrally desirable that the process should be controlled in such a manner that the material temperature highegro than 100°C is never attained.

Handling Equipments for Hydrated Lime

Lime coming out of the hydrator is in the form of a dry powder. This certainly contains a little amount of free moisture and little amount of calcium oxide (and magnesium oxide) in uncombined states. For this reason it is better to allow the hydrated lime to stand for a little time (5 to 10 mts) after hydrating before it can be further processed. It is, therefore, stored for sometime in storage bins or curing compartments.

For transporting the semi-processed hydrate from the hydrator to the stoarge or compartment usually a system of horizontal screw canveyors in tandem and bucket elevators are employed.

Examination of Impurities

Hydration of lime involves the conversion of Calcium oxide into calcium hydroxide (and of magnesium oxide into manesium hydroxides). The other impurities present in the quicklime mostly remain unaffected. These impurities should be eliminated from the hydrate. This can be carried out by vibratory sieving or by the application of mechanical air sepeartor depending on the production capacity. Generally enclosed, mechanical air separators of the centrifugal type that are conical shaped with hopper bottom are generally employed in the final milling of the hydrate in order to classify the material to a fine state of subdivision. With highly this may be—No 200 mesh material or even more.

These mills are adjustable, so that in some plants a series of several seperators may be employed to produce hydrates of different particle size or gradations. Hydrates that are not air seperated or the impurities are not eliminated from the hydrate, would be considered crude, unrefined product of less value.

After milling, the finished hydrate is fed by gravity to storage silos, located above the automatic bag filling machines.

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