LIME KILN 1985 OG45

Research and Industry
Vol. 30, December 1985, pp.356-361

Lime Hydrating Plant from Central Building Research Institute (CBRI)

S K Jain, N G Dave, I Masood & R K Yadav
Central Building Research Institute, Roorkee

Received 17 August 1984; accepted 10 June 1985

A new lime hydrating plant of capacity 60 tonnes/day has been designed and developed at CBRI, Roorkee. Design aspects of this improved, higher-capacity, lime hydrator and other related equipment required in closed circuit system for setting up a fully mechanised plant for the production of commercial dry hydrated lime have been discussed.

Among the various forms of hydrated lime, dry hydrate is the most concentrated form. This can be produced as a dry powder by treating quicklime with a quantity of water sufficient to satisfy its chemical affinity. The process of hydration can be carried out in batches or in a continuous system.

Recent trends in the design and development of lime hydrators are aimed at the continuous process which have replaced batch systems because of greater capacity, automation and superior dust control. In the recent past CBRI has designed and developed lime hydrators up to 10 tonnes/shift capacities. Extensive field trials with these machines showed their satisfactory performance. Keeping in view the increasing demand for a higher-capacity lime hydrator, the design and development of a-20tonnes/shift capacity hydrator was undertaken. The salient features of this machine have been outlined in this paper.

Design aspects of a commercial hydration plant

All high-quality, commercial hydrates must be produced entirely in closed circuit systems in such a way that carbondioxide may be excluded as far as possible and may not be allowed to cause any contamination. Controls and checks must be exercised during its production. These controls by their very nature can only be effective where the material is produced in a properly designed plant and organised on a factory basis with testing facilities.

A hydrating machine is the keystone of a lime hydration plant. In this machine reaction is carried out in the horizontal troughs which are equipped with efficient agitation paddles. Three chambers in the machine have well-defined functions and are positioned one above the other. The space and holding capacity provided in each dust-proof chamber are in proportion to the increase in volume of the hydrate during the hydrating process. In the first (pre-slaking) chamber, the two components, quicklime and water, enter and they are intensively mixed. During this mixing itself the actual slaking process starts. The main part of the slaking process, however, takes place in the middle chamber. In the third chamber, the recently produced hydrate is fluidized by the stirrer and the heat of hydration evolved inside the main hydrating chamber evaporates the residual moisture, and the lighter hydrate flow out over an adjustable dam. By adjusting the height of the dam (weir plate), the contact period available for the reaction can be varied.

In this improved design, 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 lime-hydrating machine to settle the limedust with the feed water. Hot milk of lime thus obtained is supplied to the pre-slaking chamber through the spraying jets. Theoretically, 0.3 m^3 of water is added for the slaking reaction per ton of quicklime. But in practice the quantity of water required for complete hydration of high calcium quicklime is about 60 per cent of the weight of the solid lime, as some of the added water is lost due to evaporation caused by the heat liberated during the process.

Power and its distribution in the lime hydrator

For hydrating machines of capacities ranging between 1 and 15 tonnes/hr, the power requirement ranges between 5 to 40 kW. This power is made up of the total resistance such as friction of the material against the trough, surface of the paddles, bearings, mixing, and due to hard crust on the trough wall.

The electric motor is connected by means of a flexible coupling to the speed reducer to obtain the required speed (32 rpm). The total power of the induction motor is transmitted to the middle shaft through a friction clutch and from there one-third of the total power is transmitted to the upper shaft through a pair of steel sprockets and one-third to the lower shaft.

Description of the plant operation

The plant layout designed to produce commercial dry hydrated lime has been schematically outlined in the process flow diagramme (Fig. 1). The quicklime received from the lime kiln in the form of big lumps is transferred to jaw crusher manually. Quicklime of about 1 cm size from the crusher is conveyed to the lime hydrating machine. Bucket elevator can be used for vertical transport of quicklime into the hopper of the hydrator. Two-way chute can be provided at the discharge end of the bucket elevator, so that two hydrating machines can be fed by a single bucket elevator, if desired.

Feed-rate of quicklime is controlled in the hydrator by a star feeder fitted at the outlet of the hopper. The water, which is converted into hot milk of lime, is introduced to the spraying jets through a rotameter to ensure the desired proportion of water to weight of lime. Paddles inside the hydrator have just enough inclination to cause a gradual movement of the mass. Retention time of the material can be controlled by setting of an adjustable dam at the discharge end of the lime hydrator.

Raw hydrate coming out of the hydrator is stored for sometimes in storage bins or curing compartments.

During hydration, impurities present in the quicklime mostly remain unaffected. These impurities can be eliminated from the hydrate by vibratory sieves or mechanical air seperator (depending on the production capacity). Generally enclosed mechanical air separators of the centrifugal type are employed to classify the material to a fine state of sub-division.

Modern plants provide a more simple and readily changeable means for varying the fineness of the final product from comparatively coarse to extremely fine. The plant can provide a coarse ground material suitable for agriculture

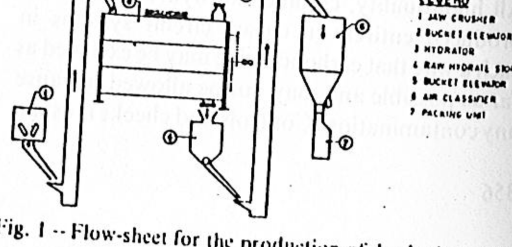

Fig. 1 -- Flow-sheet for the production of dry hydrated lime

and masonry work or finely ground hydrated lime for use in the chemical industries. By this means the quality of the final products can be controlled within a comparatively narrow range.

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

Quality of hydrate

The factory process of efficient hydration of lime by the lime hydrator consists, in addition to the flawless working of machine, of some operations like picking well-burnt lime lumps out of the run of the lime kiln and removing the underburnt, overburnt and the powder dust mixed with ashes which otherwise adversely affect the quality of the product.

Conditions for efficient hydration

Some of the factors, which have a bearing on the efficiency of the machine and definite effect on the quality of the final product obtained, are discussed below:

(a) *Optimising the size of the quicklime*—Too coarse a raw lime takes longer time to get completely hydrated, while too fine a lime may result in producing a burned hydrate in some portions and a wet hydrate in other parts. To improve the intimacy of contact between the lime and water, it is advisable to reduce the size of the lime particles to a predetermined minimum before feeding to the hydrator. As the surface area varies inversely with the particle size, it is obvious that the smaller the size of lime the greater will be its surface area available for contact with water.

It is, therefore, desirable that all lime should be reduced to at least 1 cm size representing a good size from the point of view of economy and efficiency. The necessary crushing can be performed by a jaw crusher installed prior to the hydrator.

(b) *Wet dust collector for hot milk of lime*—Cold water will not start hydration as quickly as hot water and the hydrating systems having wet dust collecting systems can ordinarly produce hot water (up to 70°C) from the steam evolved during reaction inside the hydrator, heating the water in the stack as it flows down into the hydrator.

Its other main task is to produce slight underpressure, allowing no dust or vapour to escape from the hydrating machines. The steam and lime dust generated inside the troughs are brought in contact with the incoming water. The hot milk of lime thus obtained is passed to the preslaking chamber through the spraying jets.

Need for a curing silo—In all the modern lime hydration plants, a suitable storage bin is provided for raw hydrate. The storage bin should be capable of handling an entire day's production from the hydrator.

These ageing bins in the ordinary hydration system, where hydration is considered essentially finished as the material comes out from the hydrator, is of great value in removing the irregularities in the quality of the product, resulting in wet or incompletely hydrated lime. Further, a very important advantage is the opportunity that an ageing bins gives for the continuation of hydration of the magnesia portion of the lime which normally reacts more slowly than the calcium oxide portion; so the more uniform quality of hydrated lime results if care is taken to see that the slower slaking constituents are slaked properly.

The hydrated lime from the machine, which has very little of free moisture, is either sieved or pulverised further depending upon the proper selection of materials and operation of the other conditions as well as the requirement for the specific jobs where the lime has to be used.

The machine (Figs 2 and 3) described in this paper has been used for the hydration of lime obtained from a number of places and the results obtained show that this can be used for class 'B' and class 'C' limes.

Two lime samples hydrated in the machine during trial runs were evaluated for their chemical and physical properties according to IS:-6932-1973. The results are given in Tables 1 and 2. The lime I contained impurities of silica, alumina and some magnesium oxide while the lime II was having very little of these impurities and contained higher percentages of CaO.

Need and pattern for organised production of hydrated lime

It is necessary that to produce standard quality lime, its production be brought into an organised sector like cement and some incentives be provided to its industry. The pattern proposed for the countrywide lime production could be based on quicklime produced in rural and semi-urban areas brought to central hydration plant to produce dry hydrated lime, packed and marketed like portland cement. The size of hydration plant could be suitably chosen to match the regional or sub-regional production of quicklime.

For the cost of one cement plant producing 5 lakh tonnes annually and having a gestation period of about 5 years before it can go into production, at least 175 medium-sized hydrated lime plants, each of capacity 18,000 tonnes annually (total capacity of 30 lakhs tonnes) can be set up. Total production of these plants would be six times more than that of one cement plant for the same investment.

These plants can be widely distributed and located near the large construction activity centres like metropolitan cities, industrial and housing activity regions, etc. An added advantage of the small-scale hydrated lime plants would be that they would be closer to the users and the transportation expenses would be considerably reduced.

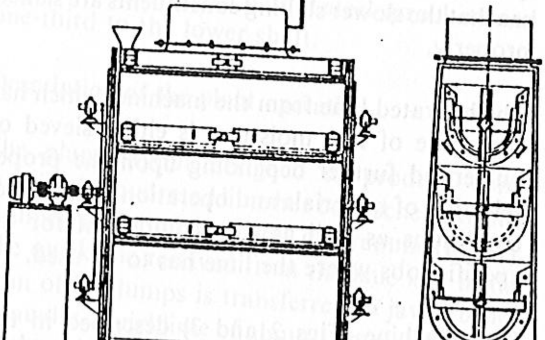

Fig. 2—Internal arrangement of the lime hydrator of CBRI design

Table 1—Chemical Constituents of Hydrated Lime (%)

	Lime-I	Lime-II
Loss of ignition	23.45	25.75
1. SiO_2	4.58	1.85
2. R_2O_3	5.36	0.65
3. CaO	82.22	96.29
4. MgO	5.86	0.56
5. CO_2	1.89	1.63

Table 2—Physical Properties of Hydrated Lime

	Properties	Lime-I	Lime-II
1	Residue on 2.36 mm	0.0	N.a.
	850 μ	1.46	0.0
	300 μ	3.97	1.6
	212 μ	3.64	3.8
2	Soundness (Lechatehier expansion)	1.0 mm	N.a.†
3	Workability		40
4	Pops and Pits	N.a.	Nil

* Being class B lime hydrate
†Being class C lime hydrate

Specifications

The specifications of a typical hydrator designed by the CBRI are:

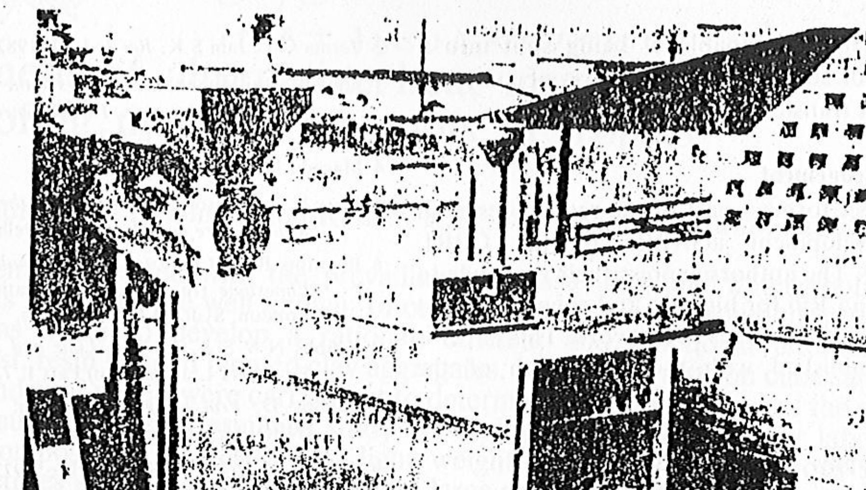

Fig. 3— CBRI's Lime-hydrator

Capacity - 20 tonnes of hydrated lime per shift

Material to be hydrated - High calcium quicklime

Pressure - atmospheric

Water requirement - 1200 litres/hr (approx)

Agitating shaft speed - 32 rpm

Power requirement - 15 hp

Total weight of the machine - 6 tonnes (approx)

Cost of this machine - Rs 1,60,000/- (approx)

The machine is capable of being split into a number of sub-assemblies for ease of maintenance and transfer.

Acknowledgement

This paper forms a part of the regular research and development activities of the CBRI, Roorkee. The authors express their gratitude to Dr Mohan Rai for his help and encouragement given at various stages of the work. This paper is being published with the permission of the Director.

Bibliography

1 Jain S K, *Chem Era*, 14(10) (1978) 1-4.

2 Verma C L, Jain S K, *Res Ind*, 27 (1982) 159.

3 Jain S K, Rai Mohan, *Proceedings of the National Seminar on Building Materials, Their Science and Technology*, New Delhi 1982, II B(7).

4 Macedo N, *NBO J*, 18 2) (1973) 15.

5 Dave N G & Masood I, *Proceeding of the Seminar on Lime, Manufacture and Uses*, (New Delhi), 1972, 98.

6 Boyuton R S, *Chemistry and Technology of Lime and Limestone* (Interscience publications, New York, London, Sydney) 1967, 287-326.

7 Knibbs N V S & Cee B J, *Lime and Limestone* (Salem Engineers L J, Toronto) Part I, 72-79.

8 Phillips D, *Proceeding Consultation: Lime Pozzolana*, (NBO, New Delhi) (1977).

9 Annual reports of CBRI, Roorkee, 1972, for the year 72; 1974, 9; 1975, 8; 1981, 10.