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# Some Recent Developments in the Designing of Lime Processing Equipment

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The shortage of cement as well as the demand for the chemical grades of lime has led to significant improvements in the designs of lime kilns and hydrators. The predominant features of the mixed-feed, vertical, lime, shaft kiln and the 3-tier hydrating machine are described. With the installation of these improved designs developed at the Central Building Research Institute, Roorkee, it has been possible to raise the output and to improve the quality of the final products.

Lime industry has made great strides in the processes of calcination of limestone and hydration of quick lime. The plant and machinery required for these operations are the lime kiln and the lime hydrator respectively.

Lime kilns of several shapes and sizes are prevalent in the industry, but the semi-continuous vertical shaft, mixed-feed (coal-fired), masonry kilns are by far the most efficient and abundantly used kilns[1,2]. The rectangular batch and other country kilns are highly wasteful in heat and have low output rates[3,4]. These batch kilns are no longer recommended for the building industry[5].

Among various forms of hydrated lime, dry hydrate is the most concentrated form of hydrate which can be produced commercially. The popularity of hydrated lime over quick lime has been increasing steadily because hydrated lime is a stable material. The process of hydration can be carried out in batches (e.g. platform slaking) or in a continuous system. But the continuous process has replaced the batch method because of greater capacity, automation and superior dust control[6,7]. Several improvements have been effected in the designs of lime kilns and hydrators at the Central Building Research Institute, Roorkee in the recent past and the salient features have been outlined herein.

## Mixed feed lime shaft kiln

A lime kiln of this type has been shown in Fig. 1. Basically, it is a tall cylindro-conical structure, constructed in masonry and lined internally with firebricks. A uniformly mixed proportion of limestone and steam coal (grade II with calorific value exceeding 6,000 k cals/kg) is lifted by skip hoist[1] (for kilns of capacities exceeding 10 tonnes per day) or by simple mechanical device[8] (for low-capacity kilns) to the top of the kiln and charged into the kiln. The kiln is operated continuously on natural draft in a minimum of two charges per 24 hr. The feed mix travels down through the kiln against a rising stream of combustion products. The lime produced is removed from the bottom of the kiln through four discharge doors by suitable means.

The kiln operates in three zones, namely the preheating (top), the calcining (middle) and the cooling (bottom) zones. The calcining zone operates at the temperature level of 900-1200°C and the temperatures in the other zones do not

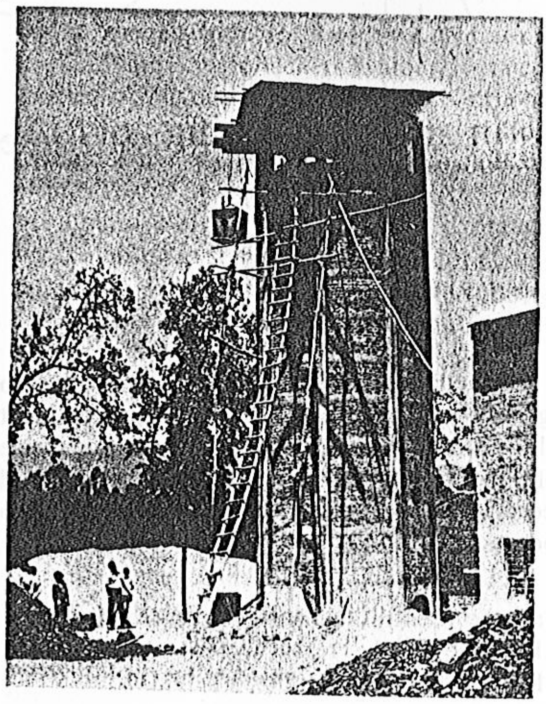

Fig. 1 Mixed feed lime kiln

exceed 900°C starting from the ambient temperatures.

The shaft of the lime kiln may be constructed in burnt clay bricks or building stones, and it is generally laid in lime mortar. The firebricks are laid in fire cement mortar. The shaft of the masonry is enclosed in a network of R.C.C. rings and columns at suitable spacings along the height and periphery of the kiln respectively for protection against lateral thrusts due to temperature stresses and for reinforcement of the structure. Adequate number of expansion joints are provided to obviate the thermal stresses which generally lead to the development of cracks in the masonry[5,9].

**Lime kiln design parameters and performance**

The basic parameters involved in the design of lime shaft kiln are the operating temperature, the draft, the type and size of limestone, fuel type and firing systems and feed input vis-a-vis product withdrawal rates. A detailed discussion of these parameters has been discussed in an earlier paper[2]. A study of the controlling parameters has led to the development of optimal designs. Lime kiln designs for capacities ranging from 5 to 25 tonnes of burnt lime per day have been developed at the Central Building Research Institute, Roorkee. Several kilns have been successfully installed and commissioned in the various parts of the country. The average inner diameters of these kilns vary from 1.5 to 4.5 m; the overall heights are in the range of 5-15 m and the wall thicknesses are of the order of 90-95 cm. The coal consumption in the mixed-feed kiln varies 14 to 22 per cent of the weight of stone depending upon the quality of the limestone and calorific value of the steam coal. The degree of underburning of limestone has been generally observed to be less than 10% in the improved lime kilns. Thus, the performance of the kilns is in full conformity with the process design features as laid down in the Indian Standards, IS:1849 and IS:1861.

**Lime hydrating machine**

A machine for hydration of lime (capacity 10T/Shift) has been designed and fabricated at the Central Building Research Institute for the continuous preparation of dry hydrated lime at atmospheric pressure. Extensive field trials have been conducted and the performance of this machine has been found to be satisfactory. The hydrating machine is the keystone of a commercial dry hydration plant. In this machine reaction is carried out in horizontal troughs or chambers which are equipped with efficient agitation paddles, producing an intimate mix of lime and water. There are three troughs in this machine which are known as (a) premixing chamber, (b) main hydrating chamber and (c) finishing chamber. These chambers are positioned one above the other. The space and holding capacity provided in each chamber are in proportion to the increase in volume of the hydrate during the hydrating process. After hydration, the volume increases approximately by 225% of the initial volume.

Hydration takes place in the presence of water. The mixture of lime and water from the pre-mixer contains water in excess of that required for complete hydration. The heat of hydration evolved inside the main hydrating chamber evaporates the excess water and the lighter hydrate flows out over an adjustable weirplate as dry powder from the outlet of the finishing chamber. The three slaking troughs are completely dust proof due to sheet metal liners and the stuffing boxes are provided at each end of the shaft. There are also inspection and cleaning doors for each trough.

During hydration, a large quantity of heat is released due to the exothermic reaction taking place. The steam generated during the process of hydration is not allowed to escape to the atmosphere but is utilised in pre-heating the water that affects hydration process. In practice, the quantity of water required for complete hydration of high calcium quicklime is about 60 per cent of the weight of solid lime.

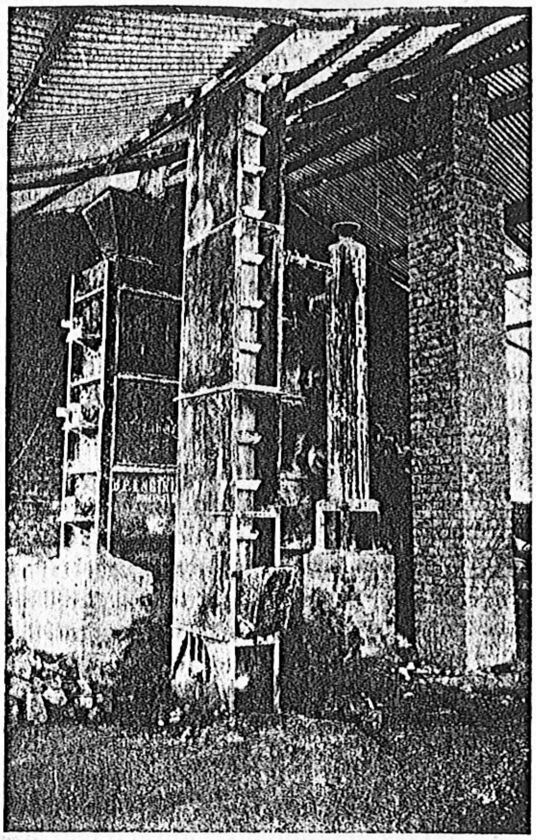
Fig. 2 Lime-hydration plant

The salient features of the hydrator (Fig. 2) are:

(1) Hydrator has three chambers, each of which has well defined functions; (2) a wet dust collector is provided with the lime hydrating machine to make the lime dust settle with the feed water. It has been seen that hot water (70°C) accelerates the hydrating process. Therefore to raise the temperature to this level, the steam and lime dust generated inside the troughs are brought in contact with the incoming water. The hot lime milk thus obtained is passed to the premixer; (3) water is sprayed by jets rather than poured on; (4) retention period (generally 25 minutes) available for the reaction between lime and water can be adjusted by varying the height of the weirplate; (5) this hydrator is suitable for hydrating high-calcium quick lime as well as soft burnt dolomitic lime, containing not more than 5% MgO; and (6) sufficient economy is achieved in the cost of hydration per unit weight of product.

**Other related equipments**

The quick lime received from the kiln is usually in the form of big lumps. These lumps can be broken efficiently by means of a hammer mill or cone mill to about 1 cm size. Quick lime from the crusher is conveyed to the hopper of the lime hydrator through a vertical, centrifugal, discharge-type, high-speed, bucket elevator. Two-way chute can be provided at the discharge end of the elevator to feed two hydrating machines with a single bucket elevator. Hydrated 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 hydrated lime is allowed to stand in curing bins for about 15 minutes after hydration, before it can be further processed. For this purpose horizontal screw conveyor and vertical bucket elevator can be employed.

The impurities present in the quick lime mostly remain unaffected. These impurities should be eliminated from the hydrate. This can be carried out by vibratory sieving in smaller hydration plants. In higher capacity hydration plants (50 T/Day), closed mechanical centrifugal type air separators are employed for the final milling of the hydrate in order to classify the material to a fine state of subdivision up to 300 mesh. After milling the finished hydrate is filled in polythene bags and can be stored like cement.

## Conclusion

The designs of mixed-feed, natural draft, lime, shaft kilns for capacities up to 25 tonnes of quick lime per day and lime hydrators up to 10 tonnes per shift of hydrated lime have been developed at the Central Building Research Institute, Roorkee and several lime plants involving the two have been set up in various parts of the country. The designs and operational features of the kilns and hydrators have been found to be fully satisfactory and outputs of the desired optimal properties have been obtained.

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## References

1 Verma C L & Saxena N B, *Chem Concepts*, 5(9) (1978) 23-29.

2 Verma C L, *Chem Eng World*, 11(12) (1976) (Section I) 57-61.

3 Dave N G & Masood I, *Proceedings of the Seminar on Lime: Manufacture and Uses*, New Delhi, 1972, 98.

4 Verma C L & Saxena N B, *Chem Age India*, 29(7) (1978) 575-579.

5 Dave N G, Verma C L, Mehrotra S P & Ansari A A, *Proc. Consultation: Lime Pozzolana*, NBO, New Delhi, 1977.

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

7 Jain S K, *Res Ind*, 21(4) (1976) 275-278.

8 Wadhwa S S, Singh M, Srivastava L K & Sivajee P, *Chem Era*, 16(6) (1980) 148-151.