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NCB TECHNOLOGY DIGEST

NCB MIXED FEED
VERTICAL SHAFT LIME KILN
TECHNOLOGY FOR LIME MANUFACTURE

National Council for Cement and Building Materials

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INTRODUCTION

LIME manufacture has been carried out in India since ancient times. The wide applicability of lime in building, chemical, metallurgical, agricultural and numerous other types of industries has resulted in concerted efforts being made all over the world during recent times for developing more and more efficient and economical methods of lime manufacture at lower fuel consumption, using alternative fuel, increasing kiln capacity and production rate, feed size control, continuous, semi-continuous operation and utilizing waste heat for preheating the stone.

NCB's approach to develop an indigenous continuously operated mixed feed vertical shaft lime kiln aims at fuel saving and producing high quality burnt lime. This Technology Digest highlights the work done by NCB and illustrates the improvements in various aspects including process technologies and kiln design for capacities ranging from 25—100 tpd.

NEED FOR MODERNISATION

NCB carried out a detailed survey of the various country lime kilns in unorganized and organized sector. As given in Table 1, the largest size mixed feed coal fired vertical kiln used in India is 50 tpd and a battery of such kilns is being used to produce 400 tpd of lime. Lime from organized sector is mostly for captive use of industries like steel, paper, chemicals, ceramics, water treatment and building materials.

The efficient operation of a lime kiln requires considerable skill and organization as lime burning is now no more a trade but an advanced scientific process which is no longer within the capacity of a cottage industry. However, survey indicated that good kankar limestone, which when burnt properly gives hydraulic lime, is by nature a pocket deposit in India and is chiefly burnt on a cottage industry basis. The inefficient burning often gives a *pseudo-lime*.

TABLE 1

GENERAL STATUS OF LIME INDUSTRY IN INDIA

Sector	Kiln Size	No. of Units	Technology	Fuel Used	Fuel Consumption (Kcal/kg)
Cottage and tiny scale	0·5 to 4 tpd	4000	Mostly batch type country kilns	Coal & cinder	1600–2000
Small and medium scale	10 to 50 tpd	300	Vertical shaft mixed feed lime kilns	Coal & coke	1100–1600
Captive kilns with steel, sugar & paper industries	50 to 300 tpd	40	Rotary kilns and vertical kilns of imported designs	Coal & gas	1600–1800 (RK) Rotary kiln 860–1000 (VK) Vertical kiln

For efficient burning, the fuel consumption should be as low as possible (~1150 kcal/kg of CaO) and the unburnt stone content should be minimum (~1·5% expressed as CO_2). It was evident that most of these kilns are highly energy inefficient and produces poor quality lime. Developments at NCB were therefore mainly directed towards developing lime kiln designs with continuous operations, better feed and discharge controls and energy potentials by way of utilizing waste heat and to improve the quality and quantity of the product.

CHEMISTRY OF LIME/HYDRATED LIME MANUFACTURE

Manufacture of lime involves thermal decomposition of limestone as per equation,

$$CaCO_3 = CaO + CO_2 - 42{\cdot}52 \text{ kcal}$$

Depending on the grain size, impurities crystallinity and $CaCO_3$ content in limestone, the dissociation temperature varies from 812 to 928°C.

For proper calcination to take place, the stone has to be heated to the dissociation temperature, then material be retained for specific time depending on the stone size and CO_2 evolved must be removed.

Hydrated lime is a stable, dry, fine powder produced by the chemical combination of quick lime with specific amount of water.

$CaO + H_2O = Ca(OH)_2$

PROCESS OF MANUFACTURE

Although a large number of technologies are available for the manufacture of lime, the two most developed and widely used technologies are (i) Rotary Kiln (ii) Vertical shaft kiln.

Rotary Kiln

Rotary kiln technology for the manufacture of lime is well established with the advantages of large scale production and use of pulversied coal as fuel. Modern rotary kilns incorporate various designs of preheaters, kiln internals and coolers for better productivity.

Vertical Shaft Kiln

Mixed feed kilns are the conventional and most widely used vertical shaft kilns in the world and are of both continuous and semi-continuous type. The most widely used modern vertical shaft kilns are; Double Inclined, Annular Shaft and Parallel flow regenerative types.

TYPES OF INDIAN LIME KILNS

Barring a few exceptions of mechanised kilns operating as captive kilns to the organised industries like steel, sugar, paper and chemicals etc, by far a vast majority of the Indian kilns can be classified as vertical shaft mixed feed kilns operating at a capacity upto 5 tonnes per day. Three different designs quite popular are:

i) the rectangular country type

ii) the stemless funnel shaped conical type

iii) the cylindrical type.

NCB MODERN VERTICAL SHAFT LIME KILN

As a premier national industrial support organisation engaged in research, technology development and transfer, education and industrial services in the field of cement and building materials, NCB has carried out extensive R&D work on the development of continuously operated mixed feed modern vertical shaft kiln suited to Indian conditions in standard capacities of 25, 50 and 100 tpd for the manufacture of various grades of building lime conforming to the Indian Standard specification IS : 712-1984. The salient features of the NCB's modern VSLK (Fig 1) are:

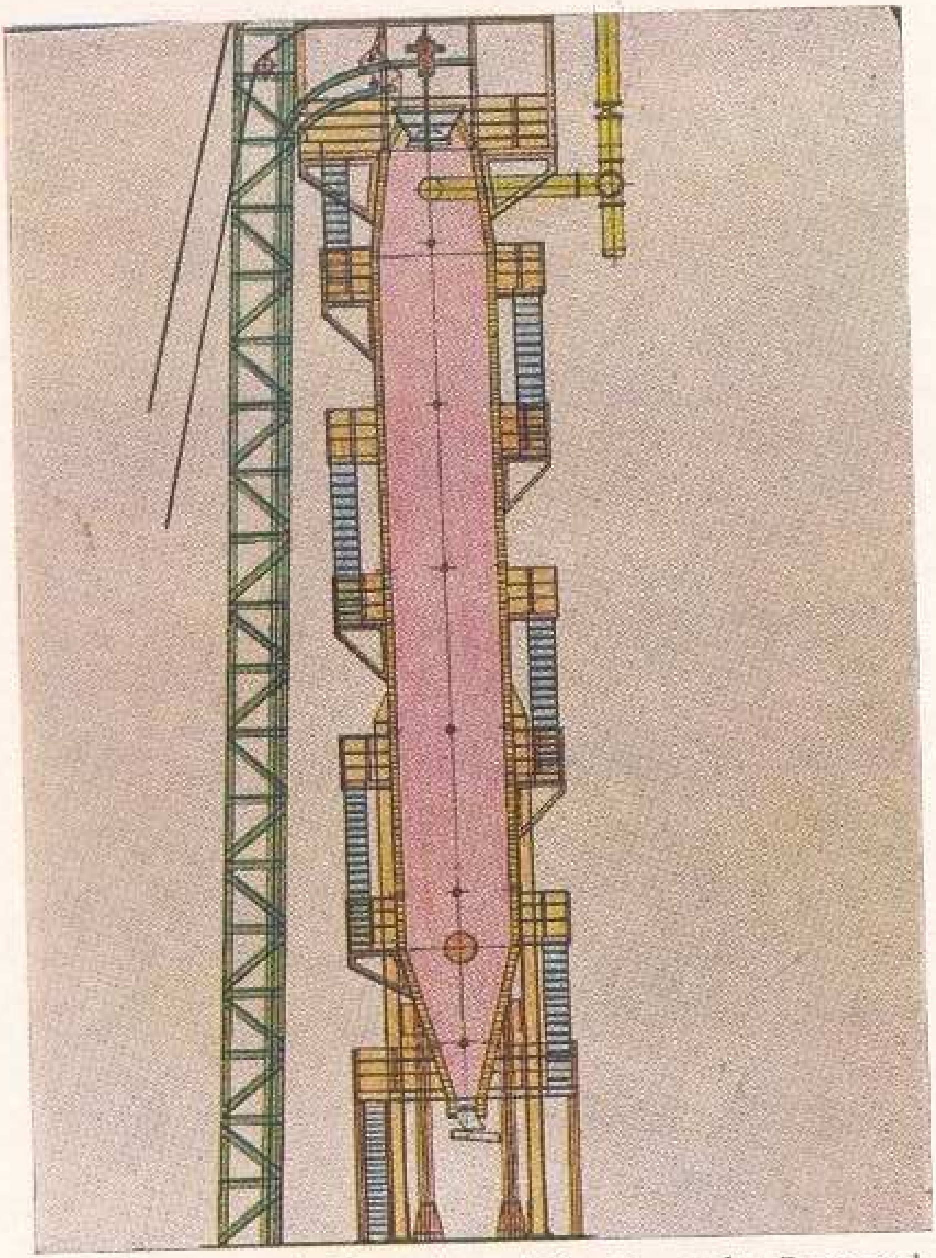

Fig 1 Sectional Elevation of Continuously Operated NCB Vertical Shaft Lime Kiln

1) It is a mixed feed vertical shaft kiln with theoretical fuel consumption similar to Modern Vertical kilns (900—1100 kcal/kg)

2) Continuous feeding and discharging to render higher production.

3) Minimum retention of bed in calcination zone.

4) Feed size grading appropriate for efficient heat flow.

5) Efficient process control and monitoring.

6) Easy design with the potential of profitability.

The Process and Operation

The two materials, ie, the limestone and fuel (coke/coal), are mixed and then this mixed feed is charged into the kiln by a skip hoist.

The kiln top has a cup and cone arrangement. Due to variable angle of the distributing cone the charge is evenly distributed over the entire periphery of the kiln bed facilitating uniform access of the hot gases to the charge resulting in smooth drying and near ideal plug flow. When there is no charging into the kiln, the distributing cone acts itself as a seal to prevent the exhaust gases from escaping from the top of the kiln.

The firing in the kiln is performed according to the principle of counter current. The shaft is divided into four zones which, according to their functions are defined as follows:

— Storage zone

— Preheating zone

— Calcining/reaction zone

— Cooling zone

The heat released by the combustion of the fuel in an atmosphere of preheated air calcines the limestone. A major portion of the kiln, interior surface where maximum thermal load is encountered is lined with high alumina brick to minimise the heat losses.

The kiln is provided with suitable openings at the bottom for entry of fresh air and the induced draught is created by an ID fan at the top of the kiln.

At the foot of the kiln a sluice arrangement is provided to discharge the product at a uniform and desired rate. This essentially consists of a plate resting on springs and connected to electromagnetic vibrator.

The Hydrator

Since lime for building purposes should always be hydrated before use, it is logical that it is supplied in that form for immediate use. This lime hydration takes place in a hydrator. The design and operation of hydrator is such that the maximum possible portion of the hydration reaction takes place in the presence of water. The temperature is controlled so that the hydrate is neither 'drowned' with an excess of water, nor left unhydrated due to insufficient water. Rapid agitation of the lime is also essential to ensure that all of it comes into contact with water. After passing through the hydrator, the hydrated lime goes to a screening system which removes grit. The hydrated lime, in the form of a fine dry powder, is then conveyed to bins for packing. The packing should be in polythene coated bag to avoid access of air.

INDUSTRIAL APPLICATION OF LIME/HYDRATED LIME

Lime and lime pozzolanas can partly or wholly replace the use of cement in certain applications with techno-economic advantages. These advantages are normally realised in (i) plain concrete for simple spread foundations in ordinary buildings, (ii) masonry mortars and plasters, (iii) terracing on top of structural roofs, (iv) small masonry bridges and culverts, (v) small to medium masonry dams, (vi) masonry piers and abutements of moderate height, and (vii) canal lining etc.

TECHNO-ECONOMICS

The estimated cost of manufacture of quick lime and hydrated lime and the investment cost of plants of various capacities are given in Table 2 below:

TABLE 2

SL No	DESCRIPTION	QUICK LIME 25 tpd	HY-DRATED LIME 30 tpd	CAPACITY QUICK 50 tpd	HY-DRATED 60 tpd	QUICK LIME 100 tpd	HY-DRATED LIME 120 tpd
1	Project cost (Rs/lakhs)	18·00	21·00	24·00	26·00	33·00	36·00
2	Investment cost per tonne of installed annual capacity (Rs)	218	212	145	132	100	91
3	Average cost of production per tonne including packing charges (Rs)	509	468	484	443	467	426

NCB EXPERTISE

NCB renders technical assistance to the interested entrepreneurs through all the steps of (i) Evaluation of limestone quarries and preparation of feasibility report, (ii) Supply of plant and machinery through NCB licenced machinery manufacturers as per NCB designs, (iii) Assistance in commissioning of the unit with assured quality and quantity of output, (iv) Training of manpower for the required skills and above all (v) Guidance and technical support from concept to commissioning of the plant.

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