



A CASE STUDY IN LIME PRODUCTION

TRADITIONAL BATCH TECHNIQUES IN PATARRÁ, COSTA RICA

Introduction

Lime has been used in agriculture and construction in Costa Rica for many generations, much of it on coffee plantations.

In 1960 the lime industry began to have strong competition in the construction sector from the newly installed cement factory at Cartago, 20 km south of San José, but, at the same time, there has been continued demand for high quality lime from the sugar processing and other industries.

Patarrá (located 10 km south of San José, the capital city) was in the past the most important lime production centre in the country but has declined in recent years. There are thought to be two main reasons for this decline:

- The deposit is located too near the city so land which might otherwise be used for lime production is used for building, or is too close to buildings and lime production there would be a potential pollution hazard.
- The chemical purity of the larger deposits (at about 86% CaCO_3 on average, although this figure can be higher for individual deposits) is less than in some other parts of Costa Rica. For example, in Nicoya, in the Guanacaste province, the deposits are of 98% purity, and in Fila de Cal in Puntarenas they contain 99% CaCO_3 .

This case study illustrates the traditional techniques utilized for producing hydrated lime specifically in Patarrá, but the same methods are also employed in other areas of the country. It should also be added that the Instituto Tecnológico de Costa Rica (ITCR) and Appropriate Technology International (ATI) have been developing improved lime burning techniques in Patarrá, in collaboration with The National Lime Producers Cooperative (Coonaproc), since 1959. However, these have not been described in this leaflet but another leaflet such as this describes such improved techniques introduced at Colorado in Nicoya in the Guanacaste province in Costa Rica.

Raw materials and quarrying techniques

Patarrá contains large deposits of marble. A company which has built a cement plant in the area has mapped these deposits out extensively.

The Patarrá lime producers rely on the colour of the rock and its hardness to assess if it would be suitable for lime making. They rarely get a laboratory analysis done on it.

25% of the fuel used for burning the carbonate is wood from trees growing in the coffee plantations and 75% is waste material from wood processing industries. On average the fuelwood is brought in from about 8 km away. In the past the lime producers caused deforestation, but at present the fuel used is from renewable sources.

The size of the fuelwood used varies from 50mm diameter for kindling, to 400mm diameter logs which can be up to 3m long. Lime producers experience considerable difficulty in obtaining suitable fuelwood and often need to bring wood from distant places.

There would be enough wood from cuttings from plantations, but preparation and transport of this material is more expensive than fuelwood from traditional sources.

Agricultural production in the country is growing rapidly, and there are plenty of residues of crops that can be used as fuel. Many lime producers are considering using this waste, even though the cost of wood is still low.

Stone is extracted by hand from small surface excavations using picks, crowbars, hammers and dynamite. When large rocks need to be broken, a hole is dug and dynamite is used, but much of the rock taken straight from the quarry face is of suitable size for putting in the kiln.

The kiln and firing methods

The kiln is cylindrical in shape, it is lined with stone blocks, and is usually placed in the slope of a hill. The internal dimensions of the cylinder vary but an average size would be approximately 3m in diameter and 4m in height. The kiln has two ramps, one to the top of the kiln, and one to the base. It has one firing opening in its front side, which leads into one trench running to the centre of the kiln.

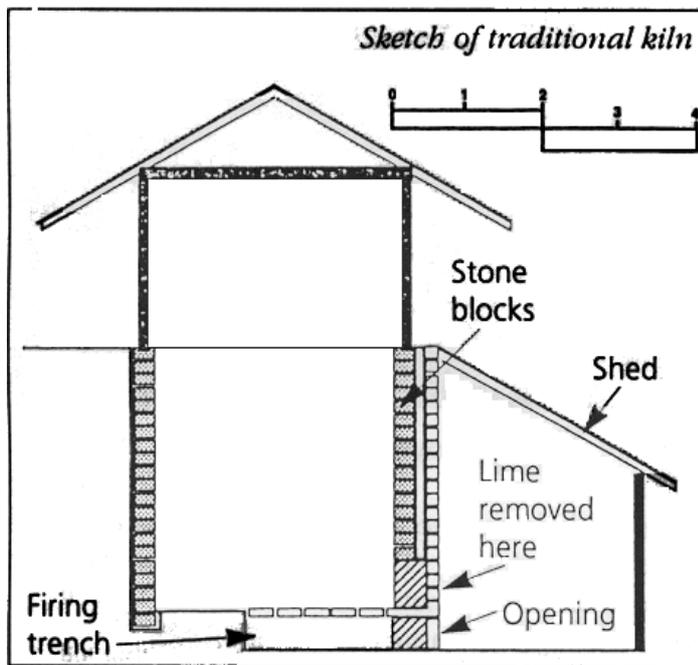


Figure 1, Sketch of traditional kiln

the kiln, and one to the base. It has one firing opening in its front side, which leads into one trench running to the centre of the kiln.

To build up the stone in the kiln an arched vault is first built over the trench using large boulders.

Other large rocks are then piled on top of these boulders and then stones are added which gradually decrease in size from 40cm near the bottom to 2.5cm in the top. The kiln is fed with fuelwood through the opening at the bottom.

Approximately 30 tonnes of marble and 24 tonnes of wood are required for each batch. The kiln is ignited and fed with wood for two or three days. A change of colour of the stone at the top of the kiln indicates when to stop adding fuel. Usually a layer of recently hydrated lime is then placed over the top of the kiln to seal it. This allows the hot kiln gases to circulate round other areas of the kiln apart from the top because there the conversion of stone to quicklime has already taken place. This stage in the process lasts a few hours.

Usually lime producers obtain one batch per week, spending 10 hours charging the kiln, 60 hours burning and two or three days allowing the kiln to cool down before discharging. The firing hole is used to discharge the kiln directly into a truck. Finally a man goes inside the kiln to finish the discharge.

The kiln always has a shed for storing the firewood and sometimes this area is used to store and bag the lime as well.

Hydration and sieving

Only a few producers mill the lime or use new bags as part of their production. The quicklime (calcium oxide, CaO) discharged from the kiln is mostly fragmented to particles less than 2mm in diameter, due to the friable character of the rock and to air slaking.

Slaking is performed by building a heap of quicklime, and adding water to the surface of it. The hydrated lime (calcium hydroxide, CaOH) forms as powder and falls to the bottom of the pile. In some cases it is then dropped through a hand-made steel wire-mesh sieve to remove the coarse unburnt material of sizes more than 10mm across. The sieved product will contain a lot of partially hydrated lime including some sizeable pieces of underburnt core material less than 10mm across. Most of this lime is sold for building use or for conditioning of agricultural soil. Only a small proportion of the product is then milled in a hammer mill powered by an electric engine, of the type normally used to mill corn. The milling is undertaken in order to produce a reasonably fine and uniform product for industrial uses. The milled hydrated lime is then bagged by locally-made mechanized packing machines.

The quality of the lime produced ranges from 40% to 45% available lime content. Available lime content is the measure normally used to compare the quality of lime. It is the amount of chemically active or 'free' lime and is expressed as the CaO contents in hydrated lime, the theoretical maximum available lime content being 75%.

Mode of operation

Production is carried out on a batch basis, with each cycle averaging 8 days. On average 15 batches are produced per kiln per year, although some producers may turn out 35 batches per year in a single kiln. Each batch typically produces about 27.4 tonnes of hydrated lime which is sold in 13 pound weight bags.

Experienced producers normally do not produce lime containing much underburnt material. Little lime is produced the peak of the rainy season due to the difficulty in obtaining dry fuelwood and the heavy rainstorms which adversely affect the burning process.

There are more than 35 lime producers at Patarra producing lime in the manner described. Half of the producers are organized into a cooperative called 'Cooperativa Nacional de Productores de Cal'. This cooperative sets selling prices and has provided financial assistance to its associates.

Comments

Traditional lime burning techniques have the following advantages:

- The capital costs involved in production are minimal.
- The operation of the kiln is simple and well understood by the producers. In addition the batch method of production is flexible and well suited to fluctuating demands for lime.
- The labour-intensive methods of production provide both permanent and casual employment opportunities.
- The quality of calcined lime is very good.
- The characteristics of the calcium carbonate in the area make it suitable to be calcined with biomass.
- The fuelwood from plantations and other fuel sources such as sawmill wastes could be used in the kiln; that is the kilns are not just limited to burning a certain type of wood.
- The wood used for fuel is low in cost and likely to remain so.
- The construction and agricultural industries, the largest markets in the country, can tolerate a certain level of impurity in their product, the cost of the product being a more important factor.

Disadvantages:

- The quarrying methods employed are both laborious and inefficient.
- The kiln design and the batch method of production are very energy inefficient- fuel efficiency is estimated at under 16%.

- The amount of waste produced by the lumber industry in the area is expected to decline in the next five years, making lime burning increasingly dependent on timber.
- Working conditions for employees in the whole process are poor.
- The tendency to leave quicklime exposed to air for a period before hydrating it results in some undesirable premature slaking.
- The system does attempt to separate out the 4 to 8% silicate-based impurities in the lime which come from using an impure limestone.

The overall result of these problems is that the quality of the product is low in terms of both the available lime content and the fineness. It is suitable only for agricultural purposes, and only a low percentage is used in the construction industry, which, in any case is decreasing its use of lime in the area. Marketing studies have shown that construction and other industrial activities could increase their consumption of lime if the quality standards improved without excessive increase in cost. The largest difficulty in obtaining a standard quality for the lime is inadequate hydration.

Information at a glance

Type of kiln	Traditional cylinder, open topped
Capital costs	Very low
Mode of production	One batch per 8 days, average of 15 batches per year
Running costs	Low
Type and quality of limestone	Marble approx 80% CaCO ₃
Fuel efficiency	16%
Conversion rate CaCO ₃ TO CaO	96%
Hydration	Manual
Sieving/classification	Manual
Milling	Electric hammer mill
Quality of lime produced	Low (average 45% available lime)
Principal market	Agriculture
Number of persons employed (including quarrying)	3 full time and 8 casuals

References and further reading

- [Lime - An Introduction](#) Practical Action Technical Brief
- [Hydraulic Lime - An Introduction](#) Practical Action Technical Brief
- [Methods for testing lime in the field](#) Practical Action Technical Brief
- [How to calculate the Energy Efficiency of Lime Burning](#) Practical Action Technical Brief
- [How to Build a Small Vertical Shaft Lime Kiln](#) Practical Action Technical Brief
- [A Small Lime Kiln for Batch and Continuous Firing](#) Practical Action Technical Brief
- [Pozzolanas: Lime-pozzolana Cements](#) Practical Action Technical Brief
- [Pozzolanas - An Introduction](#) Practical Action Technical Brief
- [Testing methods for pozzolanas](#) Practical Action Technical Brief
- [Pozzolanas: Portland-pozzolana Blended Cements](#) Practical Action Technical Brief
- [Pozzolanas - Calcined Clays & Shales, and Volcanic Ash](#) Practical Action Technical Brief
- [Pozzolanas - Rice Husk Ash and Pulverised Fuel Ash](#) Practical Action Technical Brief
- [Small Scale Production of Lime for Building](#) John Spiropoulos, GTZ, 1985
- [Gypsum Plaster: Its Manufacture and Use](#), A. Coburn, E. Dudley and R. Spence, Practical Action Publishing, 1989 (now out of print).
- [Supplementary Cementing Materials for Use in Blended Cements](#), R.J. Detwiler, J.I. Bhatti, S. Bhattacharja, Research and Development Bulletin RD112T, Portland Cement Association, Skokie, Illinois, USA, 1996
- [Small-scale Lime-burning: A practical introduction](#) M. Wingate and others, Practical Action Publishing, 1985.

- [*The Small Scale Vertical Shaft Lime Kiln: A practical guide to design, construction and operation*](#) Kelvin Mason, Practical Action Publishing, 1999
- [*Building with Lime: A practical introduction. Revised Edition*](#) Stafford Holmes & Michael Wingate, Practical Action Publishing, 2002/3

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This Technical Brief is possible thanks to the collaboration of DFID-UK and The Tony Bullard Trust.

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