



A CASE STUDY IN LIME PRODUCTION

NO.1. TRADITIONAL BATCH TECHNIQUES AT CHENKUMBI, MALAWI

Lime has been used in the Malawian building industry for many generations, principally as the cementing agent in renders and to produce a decorative whitewash. In more recent years, there has also been a demand for high quality lime from the sugar processing industry and for soil stabilization in road construction.

The Chenkumbi Hills in Central Southern Malawi, 15 km south of the town of Balaka, is a traditional lime producing area. It has grown in importance in the 1980s and 1990s due to the large deposits of calcitic marble of a reasonably high chemical purity.

This case study illustrates the traditional techniques utilized for producing lime hydrate specifically in the Chenkumbi hills, although they are indicative of methods employed in other areas of the country. Practical Action has developed improved lime burning and processing technologies for Chenkumbi in collaboration with local lime producers, since 1986. The results of this work are described in Malawi lime case study No.2 of this series.

Raw materials and quarrying techniques

The Chenkumbi hills are formed by large deposits of coarse grained, large crystalline marble. The deposits vary considerably in chemical content from almost pure calcium carbonate to almost pure dolomite. Only a small portion of the hills has been geologically mapped in detail, but this mapping alone measured reserves of 3.7 million tonnes of limestone with a high calcium carbonate content. The Malawian Geological Survey Department has trained the lime producers in a simple acid reactivity test which helps select the high quality deposits with a calcium carbonate content (CaCO_3) above 95%.

The fuel used for burning the marble is indigenous hardwood, the use of which has led to considerable deforestation in the vicinity of the hills. The size of the fuelwood logs varies from 30 mm for kindling to 800 mm diameter logs up to 3 m long for the centre of the kiln. Lime producers experience considerable difficulty in the procurement of suitable fuelwoods, particularly in the wet season when many rural roads are impassable. Softwoods are not suitable for the type of kiln used, due to their fast burning characteristics.

Stone is extracted by hand from small surface excavations using picks, crowbars and hammers. Where large rocks need to be broken, traditional techniques of heating followed by rapid cooling, using fire and water, are employed. The marble is then broken down by hand using hammers to a kiln feed size of 50 to 100 mm diameter.

The kiln and firing methods

The kiln is a rectangular box-type kiln with an open top, constructed from rough marble blocks cemented with a mud/lime mortar. (See figure 1). The internal dimensions of the box vary but an average-sized kiln would be approximately 6 m long x 4 m wide x 2 m high. The kiln walls are buttressed, normally with stone abutments, but sometimes with soil forming a ramped access to the kiln. It has two firing openings at the base on each of the short sides which lead into two trenches running along the length of the kiln connecting the firing openings.

Arched vaults are built over the trenches with large marble boulders. The kiln is charged with 5 alternate layers of fuelwood and marble starting with kindling and small logs at the base and ending in a heaped layer of marble feed at the top. Approximately 75 tonnes of marble and 55 tonnes of wood are required for each batch.

The kiln is ignited and stoked for about 48 hours, after which the firing holes are sealed and the kiln is left to burn out, which takes approximately 2 to 3 days. The kiln is then allowed to cool for a further 6 to 8 days before discharging.

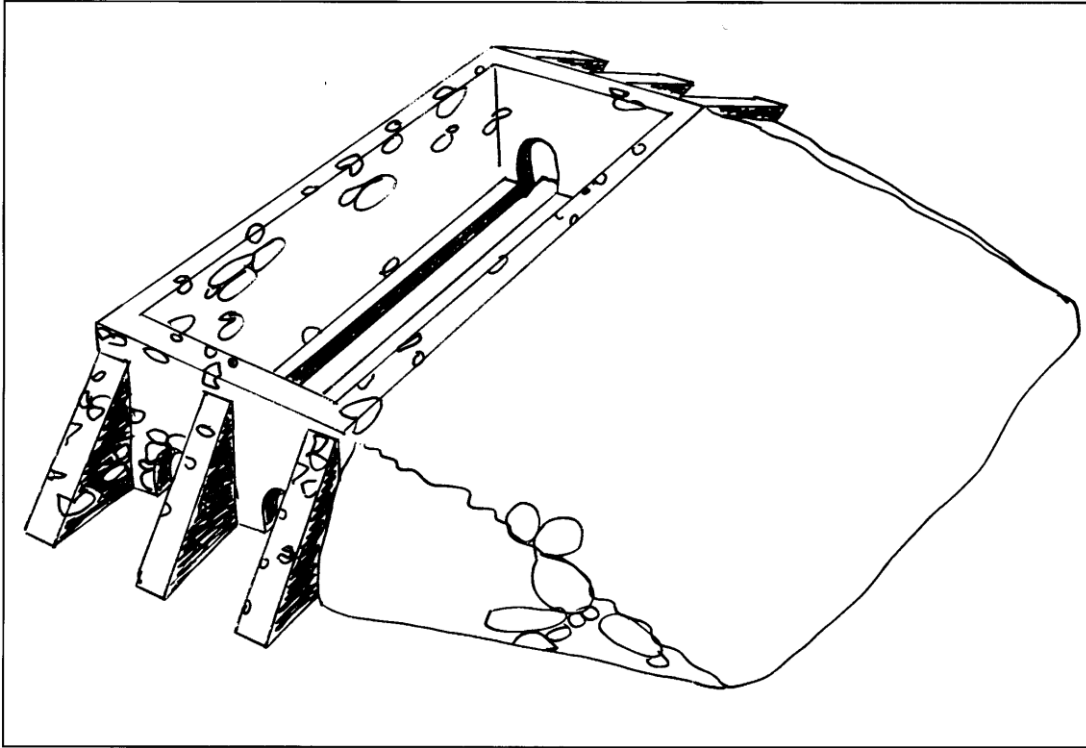


Figure1: Illustration of the Malawian traditional lime kiln.

Hydration and sieving

The kiln is discharged from the kiln top. Discharging may be done in two or three batches due to lack of storage space for hydrated lime and to the producers preferring not to undertake slaking, milling and bagging until a sale has been made. This unfortunately tends to result in air slaking.

The quicklime (calcium oxide, CaO) discharged from the kiln is mostly fragmented to less than 5mm diameter, due to both the friable character of the rock and to air slaking.

Slaking is performed by pouring water on to a reasonably large pile of quicklime, which is then turned manually using a shovel, much in the same way as concrete is mixed by hand.

The hydrated lime (calcium hydroxide, Ca(OH)_2) is then sieved through a hand punched metal sheet sieve to remove the coarse unburnt material. In practice, material of less than 10 mm will pass through the sieve and therefore the product will contain quite large quantities of smaller unburnt cores.

The product from sieving is then milled in a hammer mill, powered by a diesel engine, of the type normally used for milling maize. The milling is undertaken in order to produce a reasonably fine and uniform product.

The milled hydrated lime is then bagged by hand.

The quality of the lime produced ranges between 32 and 45% available lime content. (Available lime content is the measure normally used to compare the quality of limes. It means the amount of chemically active or “free” lime and is expressed as the CaO content. In a hydrated lime the theoretical maximum available lime content is 75%)

Mode of Operation

Production is carried out on a batch basis with each cycle averaging 60 days. On average 3 batches are produced per kiln per year, although some producers may produce 5 batches per year in a single kiln.

Each batch typically produces about 50 tonnes of lime hydrate which is sold in units of 25 kg. Approximately 15 tonnes of waste unburnt material is also produced which is normally used as feed in the next kiln batch.

Little lime is produced in the wet season due to the difficulty in obtaining fuelwood and to heavy rainstorms adversely effecting the burning process.

In 1991 there were more than 40 lime producers at the Chenkumbi Hills producing lime in the manner described. The producers are organized into a Lime Makers Association which sets agreed selling prices and has provided an avenue through which technical and financial assistance can be channelled.

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.

However, there are also a considerable number of problems and 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 below 15%;
- the kilns' demand for slow burning hardwoods has contributed to deforestation in the area surrounding Chenkumbi. This has resulted in considerable environmental damage and led to difficulties in the lime producers obtaining adequate fuel supplies, particularly as Malawi Government policy is against the felling of indigenous trees for industrial purposes. In the longer term the technology is neither environmentally nor economically sustainable;
- a combination of dense, coarse crystalline rock (which is difficult to calcine fully), and inefficient kiln design and firing procedures result in very low calcining efficiencies, estimated at around 60%. In other words only 60% of the marble in the kiln is converted into quicklime, the other 40% remaining as unburnt waste material;
- the tendency to leave the quicklime exposed in the kiln before hydration results in undesirable air slaking,
- due to inefficient slaking techniques the quicklime is rarely fully hydrated;
- the sieving to separate the hydrated lime from unburnt material is ineffective with a large proportion of unburnt material being passed on for milling;
- the mills used are not designed for lime and are therefore not particularly efficient at this particular task. The presence of hard unburnt material produces wear on the mill hammers and, as there is no separation of powdered material prior to milling, - energy is wasted in attempting to mill already fine material.

The net result of these problems is that the quality of the product is low in terms of both available lime content and fineness. It is suitable only for building grade lime where low quality, although not desirable, can be tolerated. The value-added component of low quality lime is also less.

The lime specification required by the sugar processing industry cannot be reached, despite the relative high purity of the marble, and the potential to supply chemical grade lime at a higher value cannot be achieved.

Information at a glance

Type of kiln	Traditional box, open topped
Capital costs	Very low
Mode of production	One batch per 60 days. Average 3 batches per year. 50 tonnes per batch Ca(OH) ₂ output
Running costs	Low
Type and quality of limestone	Marble. Approx 95% CaCO ₃
Type and quantity of fuel	Hardwood 15MJ/Kg. Approx 55 tonnes per batch
Fuel efficiency	15%
Conversion rate CaCO ₃ TO CaO	58%
Hydration	Manual
Sieving/classification	Manual
Milling	Diesel powered hammer mill
Quality of lime produced	Low (average 39% available lime)
Principal market	Building industry
Number of persons employed (including quarrying)	3 full time and 33 casuals
Person shifts per 100 tonnes Ca(OH) ₂ produced (including quarrying)	882

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
- [Testing methods for pozzolanas](#) Practical Action Technical Brief
- [Lime Kiln Designs: Small & Medium Scale Oil Fired Lime Kilns](#) Practical Action Technical Brief
- [A Small Lime Kiln for Batch and Continuous Firing](#) Practical Action Technical Brief
- [The Small Scale Vertical Shaft Lime Kiln: A practical guide to design, construction and operation](#), Kelvin Mason, Practical Action Publishing, ISBN 9781853394652
- [Small-scale Lime-burning: A practical introduction](#) Michael Wingate, Practical Action Publishing, ISBN 9780946688012
- [A Case Study in Lime Production No2 Improved Techniques at Chenkumbi, Malawi.](#) Practical Action Technical Brief
- [Lime and Alternative Binders in East Africa](#) Elijah Agevi et al, Practical Action /ODA, 1995
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- [Building with Lime: A practical introduction. Revised Edition](#) Stafford Holmes & Michael Wingate, Practical Action Publishing, 2002/3 ISBN 9781853395475
- [Guide for Manufacture of Lime in Vertical Mixed-feed type lime kiln: Part 1 From limestone.](#) Indian Standard IS 1861 Part 1 – 1990, Bureau of Indian Standards, New Delhi, India
- [How to Build a Small Vertical Shaft Lime Kiln](#) Practical Action Technical Brief

- [Pozzolanas - An Introduction](#) 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
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- [Lime Production: A traditional kiln at Bou Noura, Algeria](#), Practical Action Technical Brief
- [Lime Production: Traditional batch techniques in Patará, Costa Rica](#), Practical Action Technical Brief
- [A Case Study in Lime Production: Improved design of a lime kiln in Sri Lanka](#), Practical Action Technical Brief
- [Lime in Industrial Development -a UNIDO guide to its uses and manufacture in developing countries](#), Sectoral Studies Series No. 18, UNIDO, Vienna, 1985.
- [Appropriate Vertical Shaft Lime Kilns in Indonesia](#), UNDP / UNIDO Building Materials Project in Indonesia, Bandung, 1983.
- ['Oil Firing Sparks Vertical Kiln Comeback'](#), I.E. Kimberley: Rock Products, July 1973, pp 56,60,61,84,85.
- [Chemistry and Technology of Lime and Limestone](#), R. Boynton, John Wiley and Sons Inc., 1980.

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