



# A CASE STUDY IN LIME PRODUCTION

**NO.2. IMPROVED TECHNIQUES AT CHENKUMBI, MALAWI.  
4 TONNES PER DAY, MIXED FEED, FORCED AIR, VERTICAL SHAFT KILN**

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 90s due to the large deposits of calcitic marble of a reasonably high chemical purity.

Traditionally lime has been produced at Chenkumbi in large open box kilns (See Malawi lime case study No 1). The techniques employed, however, were unable to meet the demand for chemical grade lime required by the sugar processing industry, which had to import lime at considerable cost.



Figure 1: The improved kiln design.

This case study illustrates the results of development work of Intermediate Technology in collaboration with INDEFUND (a Malawian lending bank promoting small industries) and the local lime producers.

## **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 in this section alone measured reserves with a high calcium carbonate content amount to 3.7 million tonnes. 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 ( $\text{CaCO}_3$ ) above 95%.

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Marble is quarried by means of first drilling and blasting with explosives, and then by manual breaking using hammers to a feed size of between 75 and 125 mm. An experienced blaster is hired every 3 to 6 months to extract sufficient rock for the period. The rock is then taken to the kiln site at the nearby town of Balaka by hired truck.

The fuel used is charcoal produced from renewable fast growing plantation reserves planted by the Government for industrial fuel supply. Alternatively coal or wood could also be used.

### The kiln design and firing procedures

The kiln design is of the vertical shaft type, with an effective shaft height of 6m and an internal diameter of 1.1m, tapering 1m from the top to 800 mm diameter.

The kiln is lined internally with locally produced refractory bricks followed by a 230 mm thick layer of insulating bricks and a 120 mm skin of ordinary stock bricks. The brickwork is encased in a 6 mm mild steel casing with a diameter of 2.3m (see figures 1 & 3).

Four discharge points are located at the bottom of the kiln, at 90° to each other and each fitted with steel fire doors.

The kiln is free standing with a cat ladder providing access to 4 inspection ports and to a steel platform at the top of the kiln, which facilitates charging.

With this particular kiln a fan forces air through the kiln and thereby helps to control kiln temperature. The fan is powered by a 5.5 kW motor and air is fed into the kiln through a cast iron manifold at the centre of the lower section of the kiln (see figure 3).

Marble and charcoal are manually hoisted to the top of the kiln and into a steel charging hopper on a 24 hour per day continuous basis. In total 5.7 tonnes of marble and 0.8 tonnes of charcoal are fed into the kiln during every 24 hours.

The kiln temperature is maintained at between 1000 and 1100°C.

The quicklime (predominantly calcium oxide, CaO) is discharged from the kiln once every hour and-a-half from the four discharge openings by shovel directly into wheelbarrows.

In practice it is the rate of discharge which determines the rate of flow through the kiln and the quantity of feed required. The rate of discharge is determined by the required period of calcination and to some extent by the position of the firing zone.

### Hydration, sieving and classification

Slaking is carried out in a mechanical hydrator. This comprises a horizontal U-shaped trough 2 m long and 800 mm wide, covered with a lid hinged on one side and a gate along the bottom for discharge. Agitation is provided by a rotating internal shaft with a series of angle sections welded to it alternately set off at 90°.

Quicklime is charged into the top of the hydrator in batches of 220 kg. Once the rotating agitator is turning 60 litres of water is added through holes in pipes running along the top of the machine, at a rate of 10 litres per minute. The time taken to hydrate one batch is approximately 12 minutes, after which the hydrated lime is discharged.

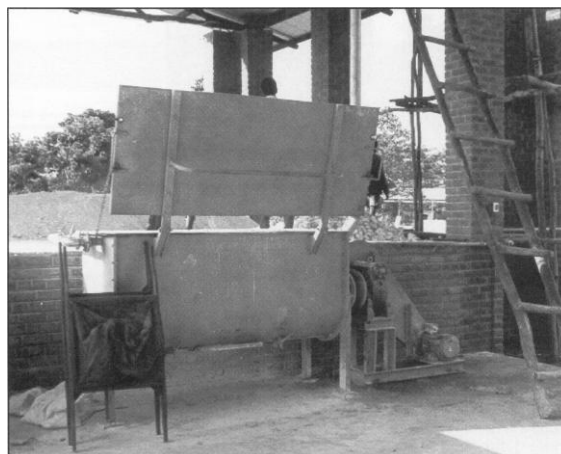


Figure 2: Prototype mechanical batch hydrator.

The slightly moist and hot slaked lime (calcium hydroxide,  $\text{Ca(OH)}_2$ ) is then allowed to dry and cool for a period of 24 hours.

The lime is then sieved into plus or minus 5mm fractions with the latter retained, and about 11 %, being waste material.

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 done in order to produce a fine and uniform product.

The milled hydrated lime is then bagged by hand.

The quality of the lime produced averages 60% available lime content. (Available lime content is the measure normally used to compare the quality of limes. It means the amount of chemically active frelime and is expressed as the calcium oxide or CaO content. In a hydrated lime the theoretical maximum available lime content is 75%.)

Mechanical and air classification equipment, designed for this particular plant, is currently being tested.

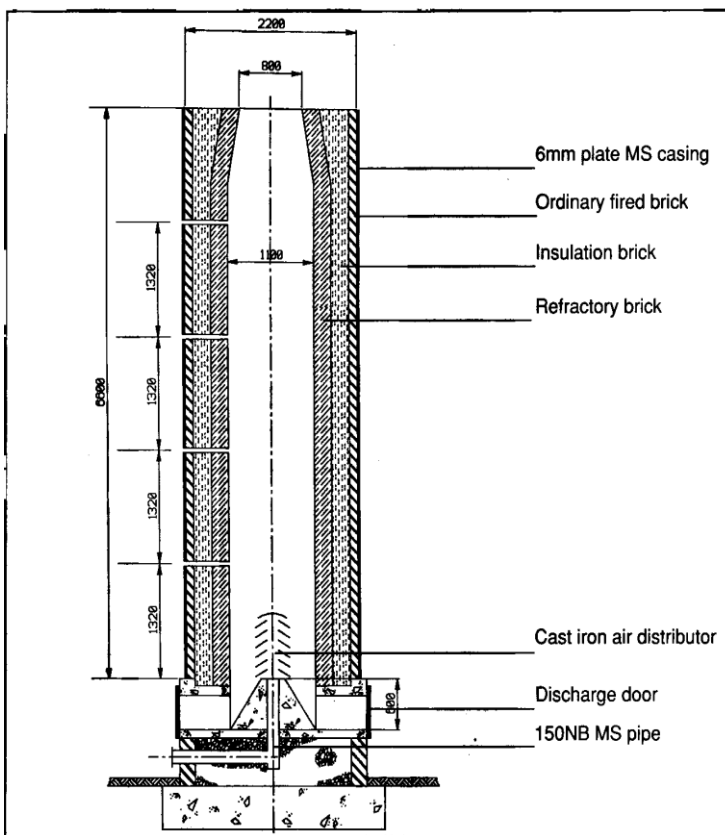


Figure 3: Technical detail of improved kiln design.

**Mode of operation**

The kiln operates on a continuous 24 hour per day basis. Although it is possible to operate a kiln of this type in fairly short production runs of a few days, considerable effort and energy is wasted every time the kiln is allowed to cool down and has to be restarted.

Production should, therefore, be continuous with only occasional shut downs for maintenance and repair.

The associated activities such as quarrying, hydrating and bagging are, in this particular case, only undertaken during the day-time shift.

**Comments**

One of the major issues of this particular lime production unit is its location. It was decided to site the kiln at the town of Balaka, over 15 km from the quarry site on grounds that the advantages of being close to power, water supplies and communications would outweigh the disadvantage of needing to transport marble from the quarry to the kiln site. While this decision may have been correct in the short term it is likely to prove economically advantageous to site the kiln close to the quarry once water and power facilities are provided at Chenkumbi.

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The kiln's fuel efficiency, calculated at 42% is reasonably good for a kiln of this type.

The loss on ignition is between 36 -37%, meaning that approximately 86% of the calcium carbonate entering the kiln is converted to calcium oxide. Again, this is a satisfactory conversion rate for a vertical shaft kiln, particularly considering the difficult calcining characteristics of coarse grained marble, the raw material used. The quality of the lime produced is also reasonably good at around 60% available lime content and a particle size distribution of 70% less than 150 microns. This is acceptable to the sugar processing industry.

The main technical objectives of this kiln design have been met. These were to produce a lime hydrate to meet the requirements of the sugar processing industry, negating the need to import lime, and to utilize renewable fuel sources rather than the traditional use of indigenous hardwoods, which is both costly and a major contributory factor in deforestation.

The kiln's operation provides employment for 57 people including those employed in quarrying. This clearly demonstrates the ability of appropriate technologies to combine labour intensive and technically efficient methods of production, thus maximising the benefits and advantages of both systems.

### Information at a glance

Type of kiln	Mixed feed vertical shaft kiln with forced draft
Capital costs	Medium
Mode of production	Continuous at 4 tonnes Ca(OH) <sub>2</sub>
Running costs	Medium
Type and quality of limestone	Marble, approx. 95% CaCO <sub>3</sub>
Type and quantity of fuel	Charcoal. 30 MJ/Kg. 0.8 tonnes per day
Fuel efficiency	42%
Conversion rate CaCO <sub>3</sub> TO CaO	86%
Hydration	Mechanical hydrator, 220Kg per batch
Sieving/classification	Manual sieving at 5mm. Air classification system under test
Milling	Diesel powered hammer mill
Quality of lime produced	Good, 60% available lime content
Principal market	Sugar processing and building industries
Number of persons employed (including quarrying)	57
Person shifts per 100 tonnes Ca(OH) <sub>2</sub> produced (including quarrying)	1570

### Postscript

This technical brief was originally written in 1991. The Balaka lime plant only continued in production for a short time afterwards. The need to transport limestone to the kiln from the Chenkumbi Hills added considerably to the production costs. Also, although the test production runs indicated that high quality lime could be produced by the plant, the quality could not be sustained under actual ongoing production conditions. The sugar industries in Malawi decided not to use the Balaka lime in their processes and continued to use imported lime.

Another lower cost continuously operated kiln that did not incorporate a steel shell or electric fan was built at the Chenkumbi Hills. This operated for a number of years but was forced to close due to economic problems and a shrinking market for lime in Malawi as well as production difficulties.

## 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
- [Lime and Other Alternative Cements](#) Neville Hill et al, Practical Action Publishing, 1992
- [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
- [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
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- [Lime Production: A traditional kiln at Bou Noura, Algeria](#), Practical Action Technical Brief
- [Lime Production: Traditional batch techniques in Pattará, 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 Production: Traditional batch techniques in Chenkumbi](#), 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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