



# LIME KILN DESIGNS

## SMALL-TO-MEDIUM SCALE OIL FIRED LIME KILNS

Lime is a very important basic material used in a variety of different industries. These include construction, agriculture, chemicals and several processing industries. There are two forms of lime: quicklime and hydrated lime. Quicklime is produced by heating rock or stone containing calcium carbonate (limestone, marble, chalk, seashells, etc.,) to a temperature of around 1000°C for several hours. In this process, known as 'calcining' or simply 'burning', the carbon dioxide in the calcium carbonate is driven off leaving calcium oxide plus any impurities.

Quicklime is an unstable and hazardous product and is therefore normally hydrated, becoming not only more stable but also easier and safer to handle. Hydrated lime is produced by adding water to quicklime in a process called 'hydration' or 'slaking', where the calcium oxide and water combine chemically to form calcium hydroxide.



6 ton per day kiln in Bali.

During slaking the quicklime lumps will disintegrate to a fine powder. If high quality limes are required some form of screening and/or classification will be required at this stage to grade the lime. Hydrated lime is normally supplied and sold in bagged form. If quicklime is hydrated with a large amount of water and well agitated, it forms a milky suspension known as milk of lime. Allowing the solids to settle and drawing off the excess water forms a paste-like residue known as lime putty. Methods of burning lime range from traditional and simple to highly sophisticated and automated. The former are by their nature labour-intensive and energy inefficient, while the latter are the opposite. In addition the former tends to produce unevenly burned lime, with a proportion that is underburnt and/ or overburnt, while the latter produces lime of a very consistent quality.

The type of kilns described in this leaflet are small to medium sized (6 to 16 tonnes output per day). These attempt to combine the advantages of traditional kilns, by being reasonably simple to construct and operate, but still retain the advantages of a high quality product and energy efficient production associated with larger; more sophisticated kilns.

### Description of the Kilns

This leaflet considers the production of quick- lime in vertical shaft kilns fired with oil. Another leaflet in this series describes kilns which can be fired with coal or wood. Vertical shaft kilns work on a very simple principal. The raw material is fed in at the top of the kiln and the product is withdrawn from the bottom, causing the material to move slowly downwards through the kiln. Heat to calcine the material is introduced roughly in the middle of the kiln and therefore any" material above is preheated by rising hot exhaust gases, and any below cooled by incoming air. In this way, material entering the kiln at the top is first preheated, then calcined and finally cooled during its passage through the kiln.

For vertical shaft kilns the feed rock should be crushed to sizes between 40 and 150 mm. Since it typically takes 1.75 kg of limestone to produce 1 kg of lime the transportation of the raw material should be kept to a minimum. Therefore lime kilns are normally located close to the limestone quarry.

The use of oil as fuel has both advantages and disadvantages compared with the more traditional methods using coal or wood as a mixed feed with the limestone. The main advantage is that there is normally no contamination of the lime with soot or ash. Better control can also be achieved over kiln temperatures ensuring a better quality, more valuable lime. The main disadvantages are that the kiln design needs to be more sophisticated, and therefore is more expensive. In some locations wood or coal is both cheaper and more readily available than oil. The latter point is significant in that use of oil in these locations may

require importation. In oil-producing countries the use of oil as fuel could be practicable even when the quality of lime is of secondary importance.

Practically all types of fuel oil can be used. In the case of bunker C oil, this has to be preheated to 100-120°C to make it less viscous. The use of waste oil, such as old engine oil, is not recommended for very high quality lime, but may be acceptable for lime of lower quality. It may be necessary to mix waste oil with a quantity of fresh oil, as it is rarely available in sufficient quantities for a continuous production run.

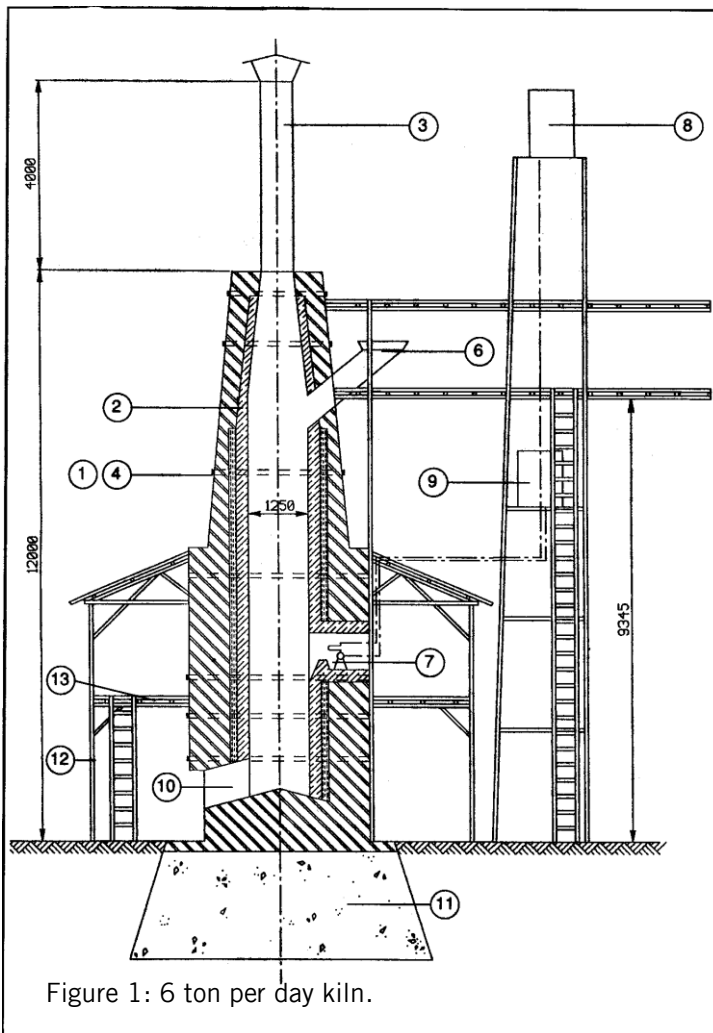


Figure 1: 6 ton per day kiln.

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### Examples of oil-fired lime kilns

Below are described a number of kilns from Indonesia with a range of outputs between 6 and 16 tonnes per day. The numbers in brackets in the text refer to components of the kilns highlighted on respective diagrams. Note that the technical details were taken from actual kilns built and in production, so those illustrated may not be the only, or even the best, methods of the type described.

#### 6 Ton per Day Kiln (Figure 1)

The casing of the kiln is a brick-built body reinforced by metallic rings (1), (4). The wall thickness is approximately 1 metre on the lower part, and 0.5 metres on the upper. The inside of the kiln is lined with refractory bricks, which are normally of fired clay, with magnesite in the burning zone (2). Behind the refractory lining of the cylindrical portion, lightweight insulating refractory bricks are located. It is recommended that aluminium foil is placed behind the insulating layer.

Other kiln dimensions (in cm) are marked on the diagram. To obtain sufficient draught for a naturally ventilated kiln, a chimney should be located on top of the kiln. This is normally made of sheet metal. The kiln is charged by a chute (6) equipped with a cover, which is closed during firing to maintain the draught. For 6 ton per day production, 10.5 tons of limestone are required, or 438 kg per hour. The kiln can be said to be divided into three zones: the preheating zone, the firing zone, and the cooling zone. In the preheating zone, which occupies the top 3 metres of the kiln, the limestone is preheated up to around 900°C by flue gases from the firing zone. The burning zone occupies the next 1.7 metres, where the temperature reaches 1100°C. Typically the speed of limestone through the kiln is about 0.2 metres per hour, so it takes 8 to 9 hours for the stone to pass through the firing zone. The 3 burners (7) are placed at 120 degrees to each other, and operate by the atomization of the fuel oil with steam. Oil and water for the burners are stored in barrels (8) and (9). The remaining portion of the kiln is the cooling zone, where the quicklime cools naturally before being discharged.

Discharge is effected through 3 channels (10) by manually operated scrapers. The quicklime is then taken away for hydration or temporary storage. The kiln is equipped with a steel or timber structure (12) for access (13), and is erected on a substantial concrete foundation (11). The energy consumption of the kiln has been estimated as 1500 kcal/kg of quick-lime, or 156 g of a typical oil per kg of lime. This corresponds to 13 kg of fuel oil per burner per hour.

#### 10 Ton per Day Kiln (Figure 2)

This particular example of a kiln has a rectangular cross section of 1x2 metres, and is made of concrete (1) reinforced with iron mats. The insulation and refractory lining is 0.5 metres thick (2). A housing (3) made of concrete is situated on top of the

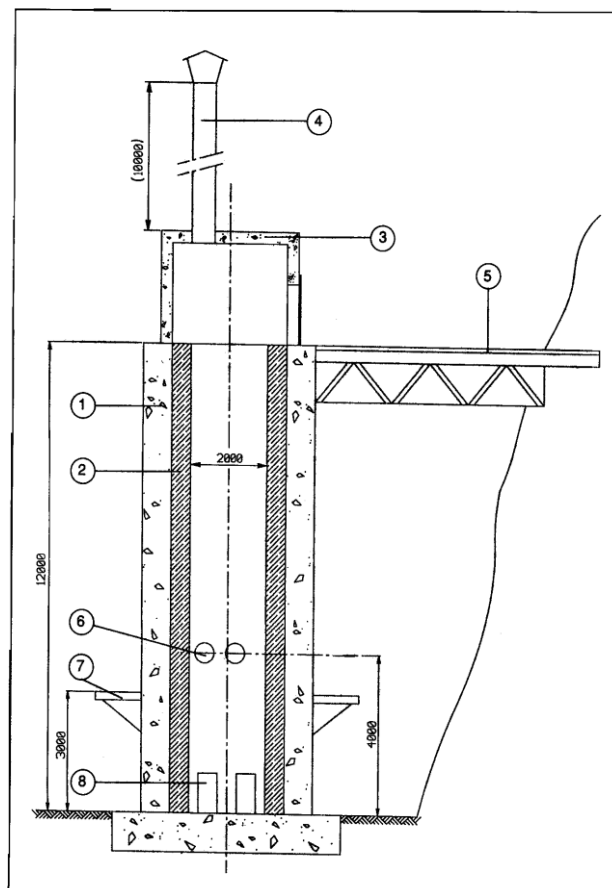


Figure 2: 10 ton per day kiln.

kiln, and the kiln is charged through a gate on the housing, by means of a bridge (5). Limestone is supplied by a road vehicle from the quarry. The kiln draught is produced by a chimney (4), 10 metres high and 0.6 metre diameter, located at the top of the housing. The burners (6) are located 4 metres up the kiln, making the heights of the zones 5.5 metres preheating, 2.5 metres burning, and 4 metres cooling. There are four burners (6), two at each side, which are somewhat displaced out of directly opposite alignment. Other features of note are the burner inspection platform (7), and the four kiln discharge channels (8).

**16 Ton per Day Kiln (Figure 3)**

The shell of this kiln is cylindrical and made out of sheet metal (1). An electricity supply is required for this kiln to operate a forced draught system; hence it is really a low production, and not a low cost kiln.

Limestone is loaded by a pulley-operated skip hoist (2), and the rate of charging of stone into the kiln is controlled by a load cell. Discharge is by a special gate (5), which can be sealed against air leakage when closed so the kiln can be left open at the top. Flue gas is discharged by a chimney (3). Another feature of this kiln is a pipe (4) to recycle some of the flue gas into one of three combustion chambers (6). The lengths of the preheating, burning and cooling zones are 5.5, 2.5 and 4.0 metres respectively.

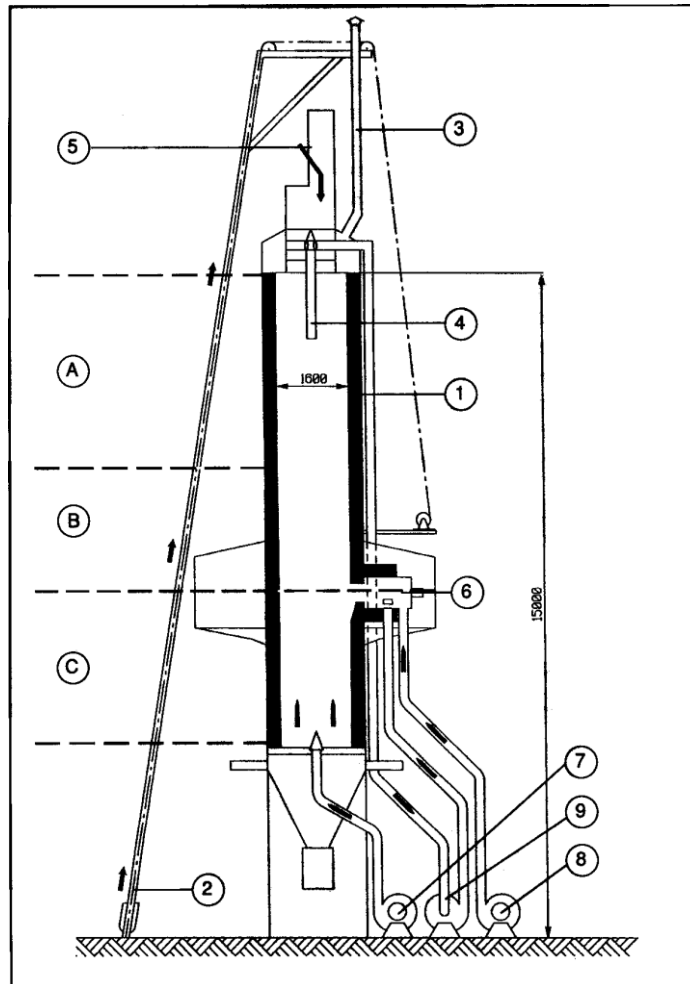


Figure 3: 16 ton per day kiln.

The combustion chambers (6) are fed with fuel oil, air and recycled flue gas. The fuel oil is gasified by the heat in the combustion chambers without the need for atomisation with steam. A fan (8) supplies air to the combustion chamber, another fan (9) recycles flue gas to the combustion chamber, while a third fan (7) feeds cooling air into the kiln. By controlling the relative amounts of cooling air and recycled flue gas entering the kiln, good control over temperature in the kiln can be obtained.

This type of kiln is very efficient in terms of its energy usage, consuming only 1100 kcal per kilo of quicklime.

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## 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 lime-stone](#), 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: 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 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.
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