Atmospheric emissions from clamp kilns in the South African clay brick industry

Dr Gerrit Kornelius

The clamp kiln is the major clay brick production technique in South Africa. It is a primitive technique that consists of a pyramid-shaped formation of dried raw bricks with a layer of combustible material, such as coal, for starting the firing process at the base, with some internal fuel included in the raw bricks.

Globally, it is regarded as an energy-inefficient process with a high probability of air pollution, as the combustion products are simply released into the atmosphere without any mitigation. As such, there has been much discussion in South African environmental circles about the continued use of this technique. However, clamp kiln technology in South Africa has remained competitive, at least in the formal brick production sector, as much larger kilns are used that often contain several million bricks. As a result, the capital cost is lower. This technology produces about 70% of the three million bricks produced in South Africa annually and employs approximately 12 000 people.

The Department of Environmental Affairs has set limits for the air pollutants that may be released from clamp kilns. Sulphur dioxide (SO_2) and particulate matter (PM10) (smoke) were identified as the pollutants caused by clamp kilns. However, the kilns' configuration has made measurement of the emissions difficult, as they are not released through a stack, but from all over the surface of the clamp.

Work carried out by the Environmental Engineering Group of the Department of Chemical Engineering during 2012 and 2013 indicated that mass balance calculations were in most cases adequate for calculating SO_2 emissions from the clamp kilns. However, other sources at brickyards also emitted particulate matter and nitrogen oxides, which made assigning these emissions to a particular source difficult. This made it difficult to propose measures for the reduction of air pollution from brick-making facilities.

In collaboration with the South African Clay Brick Association, a study was therefore initiated to design and test a small-scale model kiln that could adequately fire bricks and effectively monitor gaseous pollutants and particulate matter. The effective monitoring of kiln emissions will facilitate the calculation of pollutant emission factors for the kiln and other operations in a typical brickyard. Hence, it would also facilitate the design of air pollution mitigation measures at these facilities.

Model kiln design

The model kiln is situated in an isolated location (in order to limit the influence of external air emission sources) on the site of an existing brickyard. It is designed to simulate the transverse slice of a full-scale clamp kiln that is used for brick-firing in South Africa, but with only 25 000 to 32 000 bricks per firing cycle. It allows the emissions to be routed through a duct so that the released pollutants can be measured.

The design ensures the efficient capturing and channelling of flue gas through the stack. The partially closed sides limit gas losses.

Stack monitoring

Model kiln firing and concurrent stack monitoring have been conducted to collect energy balance and emissions data. Input data for different brick factories across South Africa was also collected. This data included data about methods of raw brick processing and packing, the intrinsic properties of "green" bricks (such as moisture content and clay type), the sulphur and energy content, and the type of fuel used.

Results

A physical examination of the fired bricks reveals it to be similar in appearance to bricks fired in full-scale clamp kilns. Combustion efficiency measurements for each batch also show results that are above the normal combustion requirements. These results suggest that the firing process in the model kiln is adequate to produce bricks with similar characteristics to those of normal clamp kilns.

Significant findings from this preliminary study include the following:

Model kiln showing horizontal stack and mesh windscreen.

Packing the model kiln.

- PM_{10} emissions are much lower (by a factor of 5 or more) than the values that are generally assumed.
- The PM_{10} result has implications for dust management around brickyards – especially with regard to emission from road traffic, which may have a much larger impact on particulate matter emissions than the kiln itself.
- This study may therefore allow optimisation and continued use of the clamp kiln method for brick manufacture.
- A simple mass balance method is sufficient to account for SO_2 emissions from clamp kilns.

The model kiln shows promise as a tool for further optimising firing practices (such as the use of non-traditional fuels to initiate combustion) to reduce energy use and air pollution from this significant sector.

Acknowledgments

This study was partially funded by the Clay Brick Association, and its members were generous with their time, products and site amenities.

Dr Gerrit Kornelius *is a senior researcher in the Department of Chemical Engineering and a member of the Environmental Engineering Research Group.*