

DESIGN AND TESTING OF A NEW ROLLER KILN FOR CERAMIC TILE MANUFACTURING WITH LOWER ENVIRONMENTAL IMPACT AND HIGHER PERFORMANCE

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SUMMARY

Motivated by the need to improve firing processes of ceramic tiles with regard to either the homogeneity of the heat distribution in the kiln section or the harmful emissions (particularly fluoride), TNO and the Dutch tile industry, in cooperation with Sacmi, have developed a new kiln concept. The study has led to the design and realisation of a prototype roller kiln, that has been installed and tested at the Mosa facilities in Maastricht. Other partners include Sphinx Gustavsberg (consortium leader), Gasunie, Gouda Vuurvast and the Dutch government as sponsor.

The earlier stage of the research, carried out by TNO, consisted of modelling the heat transfer mechanisms inside the kiln and the physico-chemical mechanisms of fluoride release. Thanks to these models and proper computer tools, parameter changes and design effects can be readily simulated and studied. These aspects of this work have been presented at Simcer '98. Great attention has been devoted to control the temperature distribution inside the kiln as well as to manage the fast firing cycles currently used.

Burner power, positions, flow, emission level, etc. have been calculated using the TNO kiln simulation models. New, but commercially available technologies have been integrated into the new kiln engineering, in order to improve the firing process, reduce emissions and minimize energy consumption.

The main technological solutions applied are:

- radiant tube burners in the firing zone
- new convective burners in the heating zone
- convection enhancement in the pre-heating zone by adopting adequate systems for the recirculation of kiln fumes
- flow control in the firing zone.

An extensive testing programme and validation of the models has been started and will continue for 1999 and 2000. Tests with the new kiln are excellent with respect to fluoride levels and tile quality. The economical convenience of the technology shall be evaluated case by case through a cost/benefit balance, as it depends on the achieved quality improvement for each specific tile product, on the prevailing environmental laws and on the prices of radiant tube burners with respect to scrubber waste disposal and maintenance costs.

TECHNOLOGY OF THE 'GREEN' KILN.

The design and technologies build into the new kiln type are based on extensive studies into the mechanisms of fluoride emission carried out and reported a number of years ago. Combining this expertise with modelling of heat and flow through a roller kiln, and with the practical experience of tile industry (Sphinx, Trega, Mosa) and kiln manufacturer (Sacmi Forni) has led to the final design of the 'green' kiln. Sacmi has engineered and build this kiln. The 30 meter long and 1.40 meter wide kiln was installed at Mosa in Maastricht in the spring of 1999. Targets are:

- lowering of the fluoride emission below 5 mg HF/m³;
- at least the same energy consumption;
- the same or better tile/glaze quality
- balanced economics

Part of the open burners in the firing zone have been replaced with radiant tube burners, supplied by WS Wärmeprozessechnik. These burners are made of SiSiC tubes and are capable of switching to FLOX mode at temperatures above 840°C. In this 'flameless' mode the NO_x emission is also strongly reduced. The tubes have a diameter of 145 mm and an effective length of 1150 mm.

In the heating zone burners are used that are fitted with perforated tubes, in order to enhance the convection, and therefore the heat and mass exchange.

At the entrance of the kiln a section is added were the outcoming flue gases are re-injected onto the incoming tiles, also in order to enhance heat and mass exchange. Research had shown, that the flow between chicanes was largely laminar, resulting in poor exchange in the standard situation.

Figures 1-3 show the principles of the green kiln.

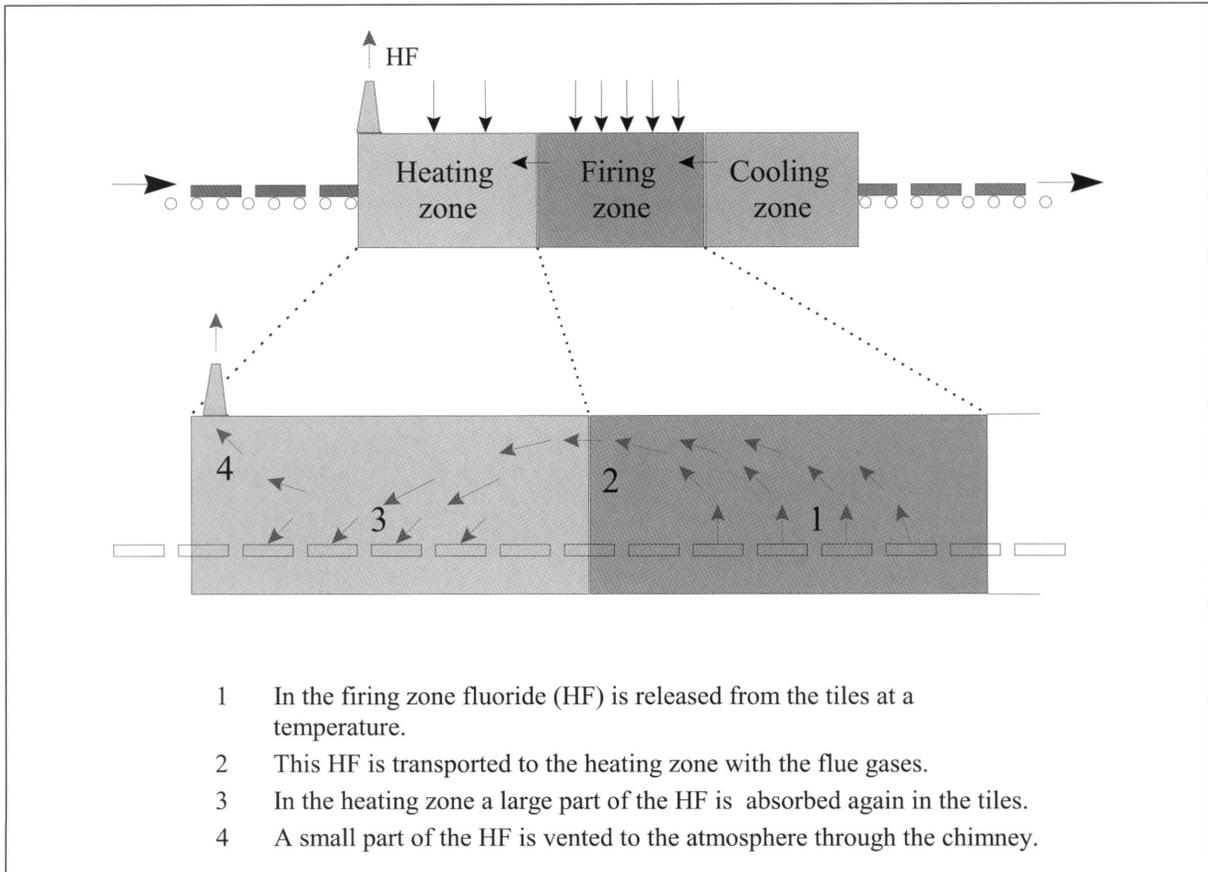


Figure 1. Conventional roller kiln.

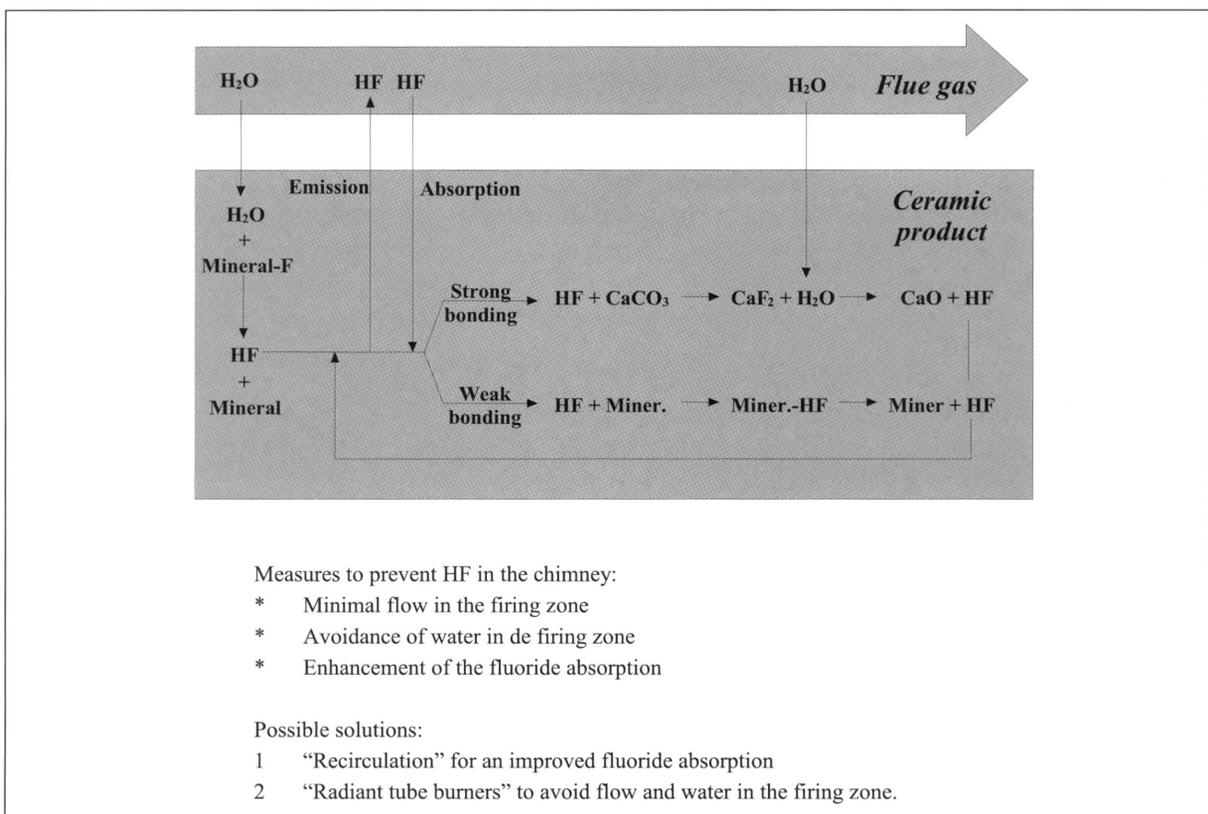


Figure 2. The fluoride cycle.

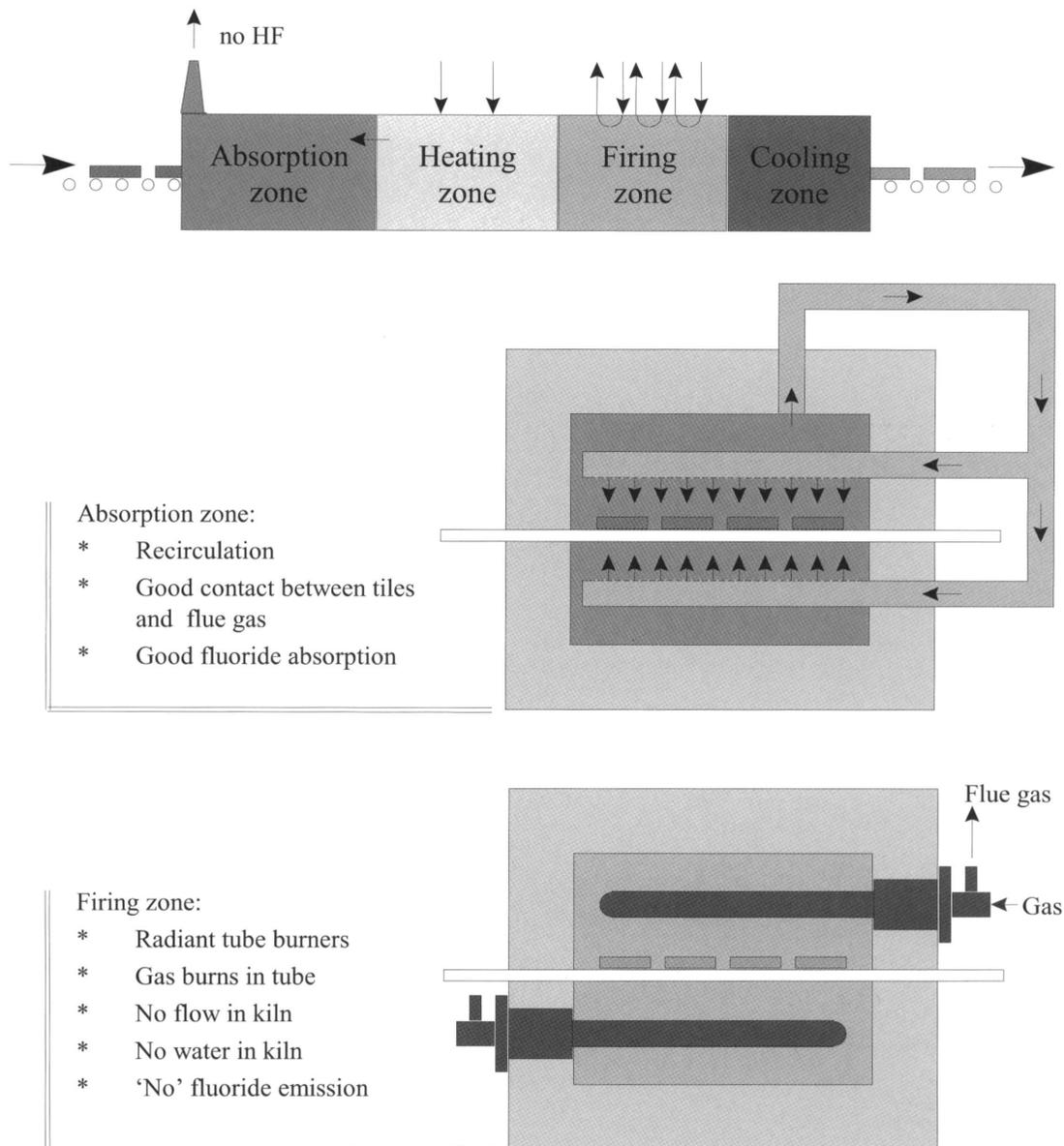


Figure 3. Low fluoride roller kiln.

EXPERIMENTAL RESULTS.

Experiments with the new kiln up to the time of writing show very promising results:

- fluoride emissions of wall and floor tiles are lower, and often significantly lower, than 5 mg HF/m³;
- the radiant tube burners perform in an excellent way;
- the impingement system at the kiln entrance contributes in a significant way to the total emission reduction;
- tile quality is very good;
- glaze quality is better than when fired in older kilns.

ENERGY

Energy consumption in a relatively short pilot kiln can be expected to be worse than in a full scale kiln. However, optimisation has resulted so far in a consumption of about 3 MJ/kg. Not included is potential re-use of the clean flue gas that comes from the recuperators with a temperature of about 500°C. For instance, this heat can be used at the beginning of a full scale kiln, or it can be used for a spray dryer, normal dryer, etc.

In such applications the total energy consumption comes out even lower than a standard kiln.

OTHER BENEFITS

Research is running into the effects of this kiln type on Pb and NO_x emissions. If positive, this could further enhance the attractiveness of this kiln.

ECONOMY

Of course, the success in the market of any kiln model depends on its total price/performance ratio. Indeed, the price of a 'green' kiln will have to compete with the price of a standard kiln + the price and cost of a traditional flue gas cleaning installation. When regarding this important aspect, the price of the radiant tube burners is, although of excellent quality, still high.

It is not possible to generalise the cost/benefit ratio for the whole world, since the cost of cleaning installations, solid waste removal, energy, etc. differ from country to country. Also, the price of RTB's will depend on quantities sold.

CONCLUSIONS

Finding and testing integrated solutions for the reduction or removal of fluoride from flue gases has succeeded. Useful and effective technological solutions have been found, designed and tested. A cleaner and more durable process is the result. At the same time, product quality has been maintained or even improved (glaze). A problem for further market acceptance might be the price of good quality radiant tube burners. We are confident that this problem will be solved in the near future.

Further tests of the benefits of this new 'EcoKiln' may expand the basis for world-wide acceptance and application.