ENERGY – SAVING INITIATIVES

Kamol Tanchotikul, Nichapat Patchararunggruang, Thanapa Wongwichakorn, Suchaya Amornkittimatee, and Palakrit Tinnakorn, The Siam Refractory Industry Co, discuss methods to reduce negative environmental impact in cement production.

Introduction

As the world becomes more concerned with energy consumption, there is a sense of urgency for the cement industry, an energy-intensive industry, to improve process and focus more on innovation for energy cost reduction in order to be competitive in the global marketplace and minimise environmental impact.

According to a the Independent Cement Producers Association,[1] fuel is the second highest cost in cement production and represents about 25% of total cost, while refractory is the lowest cost in cement manufacturing with approximately 1 – 2% of total cost (Figure 1).

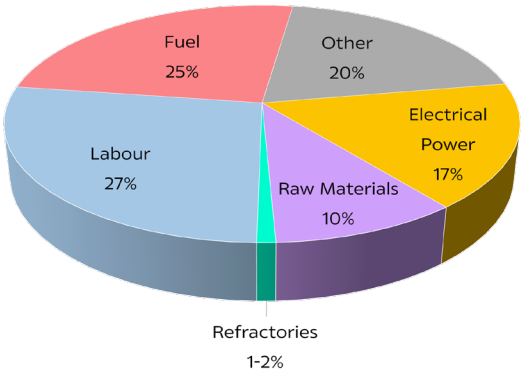

Figure 1. Breakdown of costs in cement production.

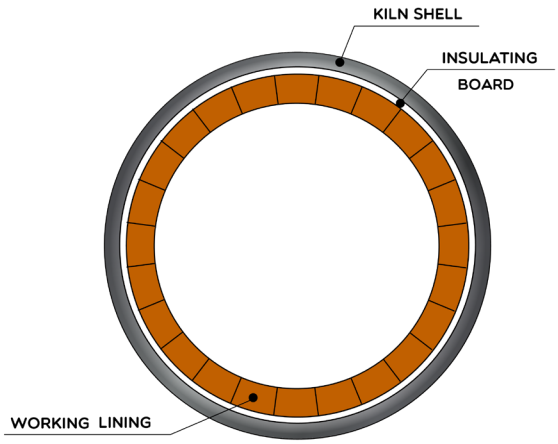

Figure 2. Installed insulating board.

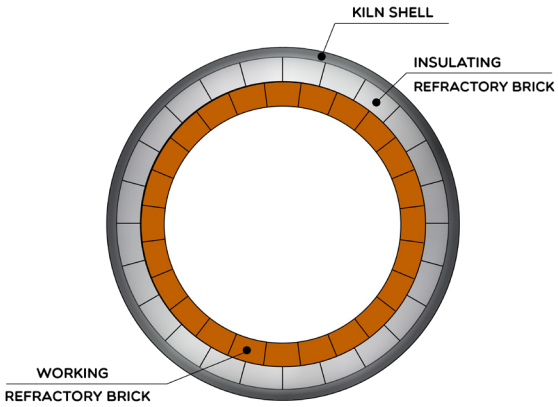

Figure 3. Installed two types of refractory.

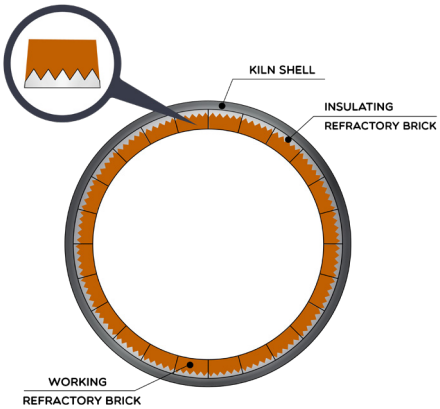

Figure 4. Installed multilayer refractory brick.

With concern for less energy cost and more efficient energy consumption in the cement industry, cement manufacturers are trying to reduce energy usage without compromising on the quality of products. Numerous measures have been taken to decrease energy consumption, such as moving the calcination process from the long dry rotary kiln to calcination in the stage cyclone preheater to improve firing efficiency of the rotary kiln. Refractory lining, which is indispensable for cement production, is one of the options that could help minimise heat loss from the rotary kiln.

Although, refractory lining cost is among the lowest in cement manufacturing, it plays a vital role in cement production costs, as it not only protects the kiln shell but also serves to minimise heat loss. For this reason, reducing heat loss in the coating and upper transition zone of the rotary kiln, which is the highest temperature zone of the cement kiln with a length of approximately 30 m, is taken into consideration by developing low thermal conductivity refractory based on a newly implemented idea that the refractory will reduce heat loss on the surface of the kiln shell and protect the kiln shell from corrosion that would be caused by heat or a volatile substance.

Problems from a too high kiln shell temperature

An excessively high rotary kiln shell temperature results in increasing kiln shell deformation, corrosion, and maintenance costs, such as loose refractory lining, a shortened service life of mechanical parts, and higher energy consumption.

How to save heat loss by adding a refractory lining to a rotary kiln

In the cement manufacturing industry, energy loss by radiation from a rotary kiln is approximately 10%.[2] Thus, efforts are made to develop the technology to reduce energy loss, especially at the highest kiln shell temperature area, the burning zone of cement rotary kiln.

Refractory installation and multilayer refractory brick technology

The heat loss of a cement rotary kiln depends on numerous factors. Selection and proper installation of insulation systems can be mentioned here as an important factor. Thus, cement manufacturers have to carefully select materials and properly install refractory to meet the process requirements. There are various ways of installing refractory insulation, including the following:

- Install insulating board specially designed for back up refractory lining in high thermal and mechanical application (Figure 2).
  - The insulating board must have thermal and mechanical resistance properties, including low shrinkage, high strength, and low thermal conductivity.[3]

- Working lining bricks are installed on the insulating board; however, this practice is suitable for rotary lime kiln, which has a slightly shorter diameter and lower burning temperature.

- Install two types of refractory bricks, which are insulating lining brick at the base lining and working lining brick on the top (Figure 3).
  - This method is usually installed in rotary kilns for the lime industry, which has less mechanical stress than cement industry.
  - However, with this installation method, installation expense and time are double when compared to the installation of a single brick layer.
  - Thus, this method is so not popular and service life depends on the skill of the refractory installation supervisor.
- Install multilayer brick with insulating layer at cold face and working layer at hot face (Figure 4).
  - This multilayer brick can shorten installation time and not require an additional specialist supervisor.
  - However, if there are two different refractory materials possessing different thermal expansions, the multilayer brick may be mismatched and produce stress between the layers, especially when temperature fluctuates.
  - Eventually the stress will create cracks between seams. Moreover, production processes of this kind of brick is more complicated and the cost is actually higher than simple bricks. Thus, this innovation is not popular currently and cement manufacturers may not take risk to install multilayer brick.

New energy saving refractory brick

The severe conditions found in the burning zone of a cement rotary kiln require the installation of basic brick, rather than alumina brick, because they have a high refractoriness and do not react with the cement meal and alkali components. However, the high thermal conductivity of basic brick results in high heat loss through the kiln shell.

Focusing on this area, Siam Refractory's research and development team figured out a solution to make its 'MAGTHERM F1': an entirely new horizon of basic brick for rotary kiln with the use of an all new type of main material for attaining a special material phase that has significantly lower thermal conductivity than regular magnesia-spinel bricks and even lower than silicon carbide containing bricks.

Thermal conductivity

Many refractory manufacturers have proposed low thermal conductivity refractory brick in order to reduce kiln shell temperature and avoid uneven temperature profiles. However, when some manufacturers tried to develop low thermal conductivity refractory brick with the higher porosity concept by using high porosity material to decrease thermal conductivity, the high porosity property of bricks caused higher alkali salt accumulation in brick, which caused the spalling of the brick surface easier, resulting in a shorter brick service life. Also, when the pores are filled with condensed volatile chemicals inside the rotary kiln, the thermal conductivity will increase as the brick becomes denser.

Furthermore, increasing the porosity will decrease the density and strength of the brick. For this reason, the insulating brick is suitable for some applications but not in areas with high mechanical loads inside the rotary kiln.

From the MAGTHERM F1 development, Siam Refractory innovates energy saving refractory brick, the best suitable solution to save energy loss that has a significantly lower thermal conductivity property. Measuring the thermal conductivity by laser flash method according to ASTM E 1461, shows that the thermal conductivity of MAGTHERM F1 is 50% less than Magnesia-Spinel Brick at the average temperature of 800°C (Figure 5). Also, the thermal conductivity of MAGTHEM is slightly less than silicon carbide (SiC) containing bricks.

Magnitude of chemical infiltration

Inside the cement rotary kiln's heterogeneous environment, complex chemicals in various temperature zones influence refractory lining and result in a corrosion of cement rotary kiln shell. Alkalis component, one of the most important factors that affect refractory, are normally introduced into the kiln through raw materials and will continuously increase its concentration under the circulation process of cement production.

At high temperatures, alkali vapours in the rotary kiln will infiltrate through refractory brick. After infiltration, the temperature inside the brick decreases continuously, so alkali vapors will condense and solidify at temperatures approximately 700 – 900°C, depending on alkali salt type (Figure 6).

At the depth of alkali component vapour-solidification level, the alkali component will accumulate and change the thermal expansion of refractory brick. Under temperature fluctuation in the rotary kiln, thermal expansion difference between the condensed layer and ordinary layer leads to cracking.

Low thermal conductivity brick can help to solve this problem by lowering the temperature inside the brick. Thus, the depth of alkali infiltration inside of the brick with a lower thermal conductivity is lower than that of magnesia-spinel brick.

Siam Refractory's in-house rotary kiln simulation, rotary drum test has presented approximately 50% lower chemical infiltration depth in MAGTHERM F1 than that of magnesia-spinel brick (Figure 7).

Moreover, the result of lower kiln shell temperature leads to a lower corrosion of the rotary kiln and extends rotary kiln service life.

Stability and thickness of coating in the burning zone

The ability and stability of the coating, one of the most important properties required in burning zone where the highest temperatures exist, is there to protect and prolong

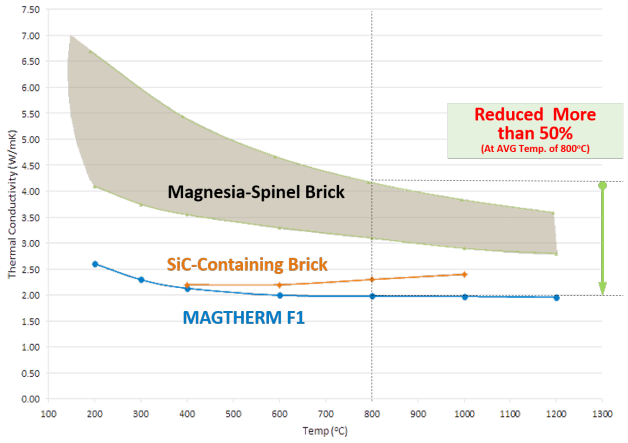

Figure 5. Thermal conductivity of brick at average temperature of 800°C.

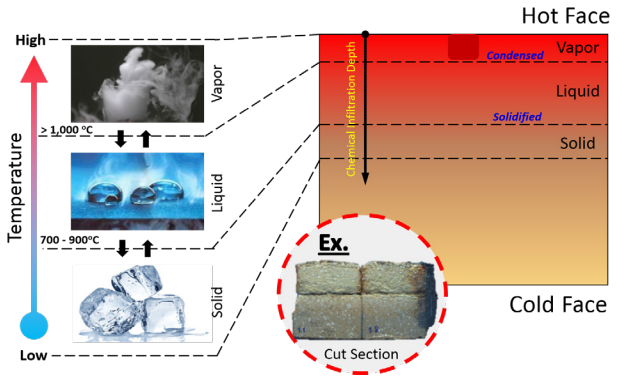

Figure 6. Alkali's state of matter.

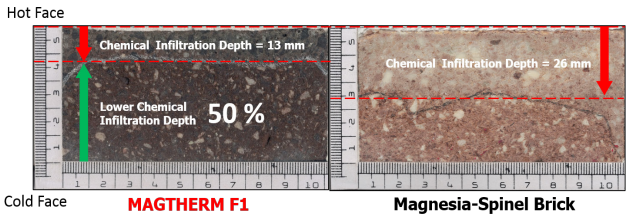

Figure 7. Chemical resistance by rotary drum test.

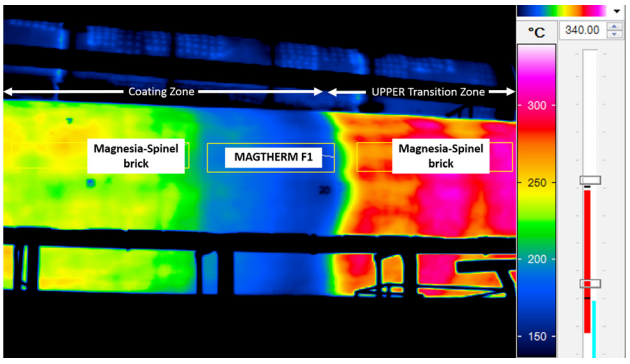

Figure 8. Kiln shell temperature by thermographic camera.

the brick service life. The type of coating is dependent on many factors, such as the chemical composition between raw meal and refractory brick.

With an innovative mix of new raw materials in MAGTHERM F1, it has the ability to pick up coating in the coating zone, as they contain raw meal compatible components Fe_2O_3, to attract faster and to provide a more stable coating than magnesite-spinel brick.

Experiences of Siam Refractory's energy saving bricks

MAGTHERM F1 was installed in a 3000 tpd rotary cement kiln (4.2 x 67 m) in the burning zone at the coating zone and upper transition zone. At the area where the MAGTHERM F1 was installed, the kiln shell temperature (182°C) was significantly lower than the surrounding area installed with regular magnesia-spinel brick. The shell temperature was 22% lower than that of the area in the regular magnesia-spinel brick for the burning zone (234°C) and 37% lower than that of area in regular magnesia-spinel brick for the upper transition zone (286°C) (Figure 8).

From the heat loss calculation, by installing MAGTHERM F1 20 m under the coating zone, and another 10 m under the upper transition zone, accumulated energy savings from the reduced heat loss for a campaign of one year for a rotary kiln diameter of 4.2 m is 4.5 kcal/kg clinker. The energy saving is given in kcal/kg of clinker, which can be multiplied by fuel cost in each country to obtain energy cost saving per kilogram of clinker produced.

Conclusion

In the cement industry, less energy cost and more efficient energy consumption through various process improvements, including refractory brick lining, are being increasingly implemented to save on energy costs and to minimise environmental impact.

Following this concept, the refractory industry continues to develop a series of energy saving products to serve specific needs. New energy saving refractory brick with low thermal conductivity, low chemical infiltration, and fast coating pickup properties, MAGTHERM F1, is one of these key developments as the optimisation concept was applied without compromising on quality and performance.

About the authors

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