High-Efficiency Refractory Linings to reduce the impact of Cement plants on Greenhouse Gases emissions through fuels savings

SUMMARY

Cement Industry has a very relevant impact on Greenhouse Gases emissions (GHG) at global level, causing the everyday more obvious Climate Change leading to environmental incidents, affecting our planet and ourselves. The industry is implementing practices aimed to the reduction of emissions, being one of the main initiatives the reduction of fossil (coals) or derived from fossil (petcoke) fuels burned for clinker production, intermediate product for cement manufacture.

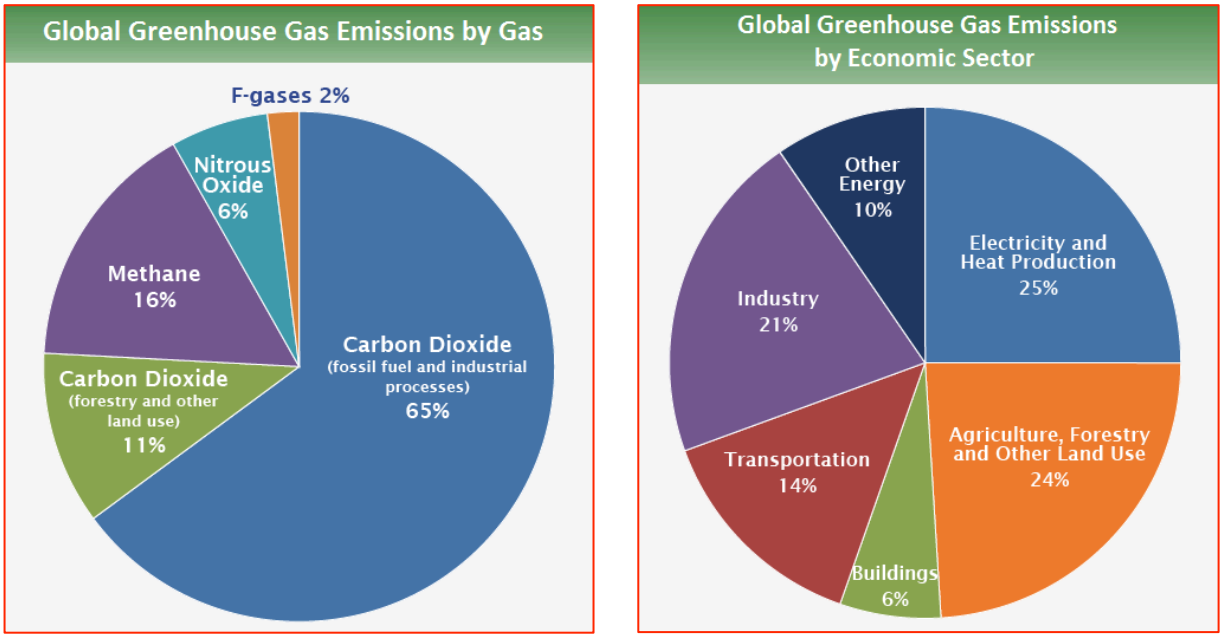
Refractory linings at clinker kilns have therefore a potential of beneficial impact on the reduction of GHG emissions causing Global Warming, through the adoption of ***High-Efficiency Refractory Linings*** (HERL), minimising the consumption of fossil fuels necessary for clinker fabrication and hence reducing both GHG emissions and variable production costs. HERL investment is quickly paid off thanks to thermal savings, while strategically becomes mandatory in the context of Climate Emergency we live in.

CLIMATE CHANGE CONTEXT

Currently the grave problem of Climate Change has been renamed as Climate Emergency given the evidence of quick global warming of the Earth and the magnitude of its effects on the natural habitats and populated areas, taking place much more often extreme phenomena like massive fires, prolonged droughts, icebergs melting, floods caused by the loss of forest mass, etc.

It is commonly accepted by the Scientific Community that within this 2020-2030 decade Humanity must adopt urgent policies and put in place measures aimed to the sustained reduction of Greenhouse Gases (GHG), main cause of the global warming.

In this context, the Power Generation sector from fossil fuels appears as the major contributor, followed by a series of industrial processes headed by Cement Industry. Cement production contributes with until 8% of global GHG emissions caused by human activity, more than all the worldwide road trucks fleet used for terrestrial transport. Moreover, Cement sector is the second global generator of CO2 and third global energy consumer, which in turn requires a higher utilisation of pollutant power stations.



Source : US Environmental Protection Agency

CO2 emitted for civil works concrete manufacture (from which 14% is cement) is estimated as 410 kgCO2/m3 of concrete, in other words, some 180 kg for each ton of concrete (at an average density of 2.3 mT/m3), although the use of fly and wet ashes (more and more scarce due to gradual paralisation of fossil fuels power stations) may reduce these emissions by until a 30%. CO2 emissions due to civil works concrete fabrication is therefore directly proportional to the cement content in concrete. 900 kg of CO2 are emitted for the fabrication of 1 ton of cement, assuming an average of 70% of emissions related to each ton of concrete.

Therefore it is urgent the adoption of immediate measures to revert this trend, which major Cement Groups worldwide are articulating around :

- **Optimisation of energy efficiency** of the clinker production process.
- **Maximisation of waste fuels burning** to minimise the use of fossil fuels (petcokes, coals, liquid oils, natural gas).
- **Reduction of clinker content per ton of cement** through the use of alternative materials replacing clinker and compatible with cement specifications.
- **Electric power co-generation for internal consumption of cement plant**, usually from spare hot air from coolers, hence reducing the demand of electric power from the grid.
- **Development and production of new clinker types**, of lower environmental impact and/or higher reactivity.
- **Adoption of technologies to capture and/or reuse of CO2** (future).

It should be remarked that these measures are subject to technical and process limitations, conditioning their effectiveness, but much more can still be done within the scope of energy optimisation.

GREENHOUSE GASES EMISSIONS (GHG) IN CEMENT INDUSTRY

Internationally gases considered as Greenhouse (GHG) are water vapour (H2O), carbon dioxide (CO2), nitrogen oxide (N2O), methane (CH4) and ozone (O3). Among them, from European Union data, 81% of emissions are due to CO2, 11% to methane and 5% to N2O. Therefore, CO2 control measures will lead to a quicker effect. Water vapour joins water cycle and therefore is naturally absorbed.

In the clinker production process for cement manufacture a massive volume of CO2 is generated from two sources :

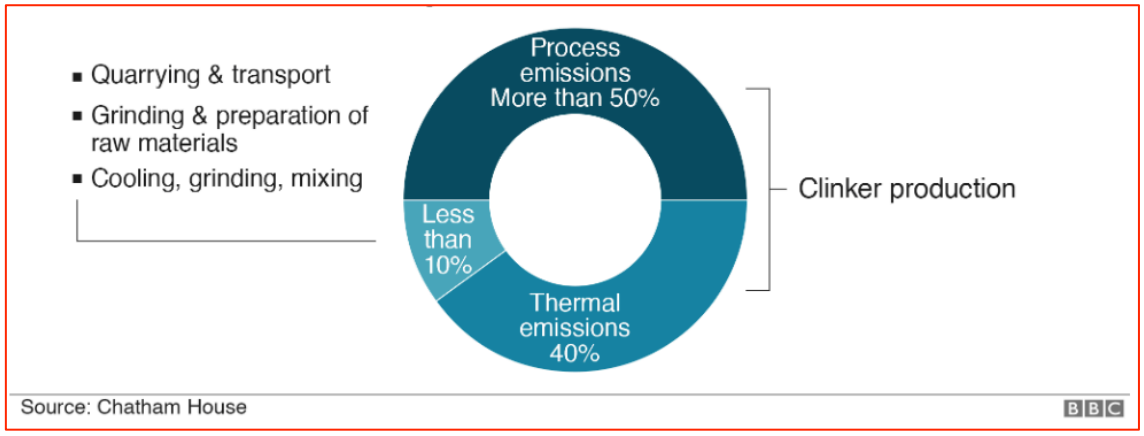
- **Thermal emissions : fuels combustion** (40% emissions related to burning process). Hydrocarbon fuels generate, at the exothermic reactions taking place during combustion, heat, CO2 and water vapour. In order to reduce CO2 emissions, it is mandatory to reduce the volume of necessary fuel per ton of clinker. The amount of hydrocarbon fuel necessary is defined by the amount of available waste fuels burned (residual wastes, not fossil or derived from fossil), and the amount of necessary heat to produce one ton of clinker.

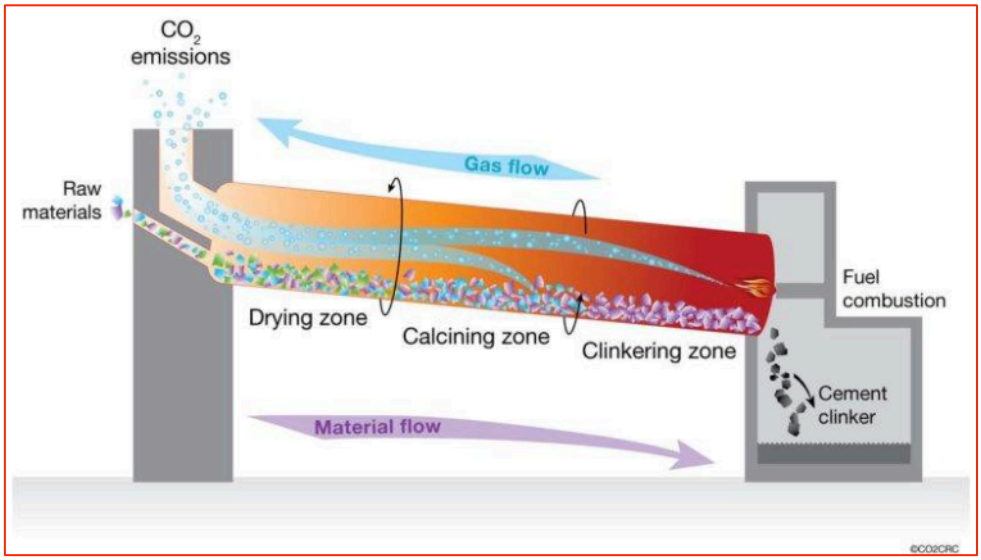
  HYDROCARBON FUEL + O2 → HEAT + CO2 + H2O

  Harder raw meals (less suitable to cooking) will need a higher Combustion (Formation) Heat and therefore will imply a higher Specific Heat Consumption (SHC) at the clinker production line.

- **Process Emissions : decarbonation of raw materials** (>50% emissions, associated and inseparable from raw materials), thermal decomposition of carbonates to release calcium oxide (lime) which will later be combined to form clinker compounds. This decarbonation reaction releases high volumes of CO2 to the atmosphere. Unfortunately these emissions are intrinsic to the production process and can only be reduced by decreasing the clinker volumes produced. As a consequence, Cement plants are trying to reduce the clinker/cement ratio, which in turn also leads to energy savings, or develop new types of more reactive clinkers whose contribution to cement is lower in percentage.

  CaCO3 + HEAT → CaO + CO2





Therefore, Cement plants are making special efforts to maximise the burning of available waste fuels, despite the process and operational stability problems connected to them, as well as trying to reduce the Specific Heat Consumption (SHC, amount of total heat consumed per ton of clinker).

Within this latter group of control measures is where refractory linings play a vital role to contribute to the reduction of emissions, through the decrease of fossil fuels usage (petcokes and coals).

HIGH-EFFICIENCY REFRACTORY LININGS (HERL) FOR REDUCTION OF GREENHOUSE GASES (GHG) EMISSIONS

Traditionally Cement plants have paid much attention to the selection of refractory linings with robust hot-face materials in order to cope with process conditions and perform for long lifetimes. Insulation layers have usually received less consideration, seen as something necessary to reduce heat loss, in many cases without conceding too much importance to them.

With the gradual introduction of waste fuels, chemical conditions of combustion gases and composition of material build-ups formed over the linings, specially connected to the use of higher sulphur, cheaper petcokes, have favoured the appearance of acid corrosion phenomena on steel casings, in particular at the areas of injection of waste fuels in preheaters, as well as condensation areas (inlet chambers) of the gases generated at the main burner.

Traditional linings were designed with conventional insulating materials, like lightweight bricks, calcium-silicate boards and insulating concretes of several capabilities and densities, offering thermal conductivities acceptable to date. However, under the Climate Emergency problem and higher need of plants to adjust fuels variable costs, it makes more sense than ever to review the linings specifications to minimise fuels consumption, while enhancing their performance and resistance against process demand.

It is important to remark that heat losses in linings happen due to the three ways of heat transmission : conduction, convection and radiation. The evaluation of these losses can be simply estimated through the use of thermal cameras and later calculation of losses (kWh or kilocalories) per each kiln component (cyclone, smokes chamber, calciner, ducts, etc.). Regular inspections and thermographic reports are a crucial tool for plants Process teams to control the energy consumption at any given time and therefore emissions to atmosphere, as well as for planning of refractory maintenance shutdowns.

Thermal bridges, mainly metallic elements inserted in the lining like steel anchors, consoles, beams, mandoors frames, steel stiffeners, air blasters nozzles, Cardox pipes, samples/tapping points, process probes, etc., as well as the necessary expansion joints for the refractory linings, are all detrimental for the thermal efficiency as they increase conductivity and heat losses, and must therefore be taken into account when designing the optimum lining.

In view of the complex thermomechanical demand and chemical attack over the hot face, as well as the higher need of insulation, REYMA has developed ***High-Efficiency Refractory Linings*** (HERL), allowing the plant to opt for :

OPTION 1 – High-Efficiency refractory linings with longest lifetime :

This solution allows plants to obtain all the benefits from a high-performance lining, extending its lifetime to the maximum possible keeping the current total thickness, in other words, keeping current kiln throughput (tons per day) :

- Keeping current total thickness, maximising hot-face thickness while minimising insulation thickness.
- Using state-of-the-art dense materials to extend lifetimes to the maximum.
- Combination of application techniques of dense materials depending on areas and requirements, choosing between vibrocasting or high-pressure gunning, hydraulic or ceramic bonding, as well as high-performance pre-cast blocks.
- Using super-insulating materials to reduce heat losses to the minimum compatible with appearance of corrosion (dew point).

OPTION 2 – High-Efficiency refractory linings with maximum savings per ton of clinker :

This solution allows the plant to increase kiln throughput (tons per day), particularly when applied at bottleneck areas, as it reduces the total lining thickness, dropping therefore preheater differential pressure (delta P) and increasing oxygen available for combustion for the same level of draft (main ID fan). The higher amount of O2 available allows to increase kiln output (feed and fuels), hence increasing kiln performance and reducing, as added value, specific power (electric) consumption (per ton of clinker) due to the dilution of the power consumption of the fixed consumers (main drives) over a higher hourly output :

- Keeping the current thickness of hot-face, review and upgrade the specification of the dense material to extend lifetime, applying cost optimisation criteria.
- Combination of application techniques of dense materials depending on areas and requirements, choosing between vibrocasting or high-pressure gunning, hydraulic or ceramic bonding, as well as high-performance pre-cast blocks.
- Using super-insulating materials to reduce heat losses to the minimum compatible with appearance of corrosion (dew point).

HERL selection criteria and REYMA technical service

Plant priorities and cost-benefit criteria will allow to select one option or another, or a combination of both, to optimise energy consumption, reduce emissions and maximise kiln throughput.

REYMA offers all our customers the following materials and services to optimise Energy Efficiency of their linings :

- **Process studies** from customer plant information over the existing lining, current and future demand, in order to propose HERL optimum specifications.
- Variety of **stationary heat transmission studies** with diverse linings options applicable to each area.
- **CAD designs** of the different lining options.
- **Supply of dense materials**, in particular REOTIX® ZSI y GUNTIX® ZSI technologies, as hot-face layers to guarantee the maximum performance and lifetimes. Variety of dense products include vibrocast or high-pressure gunning versions with our exclusive GUNTIX®-HP technology.
- **Supply of pre-cast blocks, vibrocast and thermally treated** (tempered and sintered), as well as compatible anchoring systems, to minimise installation times and costs.
- **Supply of super-insulating materials**, based on the latest technology in insulation systems, in order to minimise heat loss, available in a variety of materials, shapes and protections against moisture and corrosion.
- **CAD engineering drawings for the selected lining** as guidelines for installation teams.
- **Supervision** of installation works.
- **Follow-up** of thermal performance of the new linings.
- **Any additional customer need** like personnel training, etc.

Installation of a **High-Efficiency Refractory Lining** (HERL)

CONCLUSION

Cement Industry is currently living a context of strong increase of overall production, expected by 2030 around 5,000 million metric tonnes, up until 4 times 1990 volumes. Simultaneously, Climate Emergency situation requires the adoption of urgent and significant measures aimed to the reduction of fossil fuels consumption by plants. And finally, the higher and higher competitivity on worldwide clinker and cement markets and prices is putting a hard pressure on Cement groups and factories, forcing them to implement measures to reduce costs, often compromising the reliable run of equipments, particularly those units using medium-quality refractory linings.

High-Efficiency Refractory Linings (HERL) designed and supplied by REYMA offer a solution to these problems, contributing to thermal savings, improvement of equipments reliability and reductions of GHG emissions. Strategically, plants installing these new linings enjoy from a competitive and technlogical advantage against competition.

REYMA is as always at disposal of all current and future customers for the study and implementation of these linings.