Powering the Cement Industry

Cement is an energy-intensive industry, but currently, electricity accounts for circa 12% within the energy mix, while the rest is various fuels. Total electricity consumption in a dry process is split into equal parts between raw material preparation and clinker production (25% each), then 43% for cement grinding and the remaining for raw material extraction, fuel grinding and for packing and loading. Both the relative share in the energy mix and the usages are expected to change in the near future.

Improvements efforts and future trends

Many continuous improvement efforts were made in Europe over the past ten years to decrease power consumption investing in new equipment and retrofitting an existing one. Cement plants can have from 350 up to more than 1000 motors in operation (incl. conveyors, pumps, small fans, and blowers), depending on the size of the plant and the process technology. Their substitution, or retrofitting with the application of variable speed drivers, which are getting more and more widespread, brought a significant step forward.

For further significant steps in the reduction of the specific energy demand, huge retrofits like changing from cement grinding with ball mills to highly efficient vertical roller mills or high-pressure grinding rolls must be done. The investment for these kinds of the retrofit is high. Therefore, they will mainly be carried out if the market situation gets very promising or if the equipment is already very old and needs to be replaced.

Electrical energy demand also depends on product properties. The higher the cement's strength development, the finer it typically has to be ground, requiring significantly more energy in the mills. This trend can lead to a rising electrical energy demand although the equipment efficiency improves.

High-efficiency separators have now a broad application due to existing market demand for quality cement.

Concerning the clinker burning process, measures which increase thermal efficiency often need more electric power. For example, the installation of modern grate cooler techniques causes a reduction in thermal energy use but increases the consumption of electrical energy.

Specific power consumption normally raised whenever environmental requirements get tougher. In fact, lower dust emission limit values require more power for dust separation, regardless of which technology is applied. For the abatement of other components (like NO_x or SO_2) additional units should be installed which require electricity. The use of SCR technology for NO_x abatement, for example, results in an increase in electrical energy demand of 5 $kWh/t_{clinker}$.

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Other ways of improving energy efficiency

Still, there is a potential to improve cement technology in order to further increase energy efficiency. Besides the efficiency of the installed equipment, the flexibility of production is of increasing interest with regard to the intermittent availability of renewable energy sources. By designing production facilities like grinding plants in a way that they can be easily started and stopped the use of renewable energy can be maximised. This will not reduce but rather slightly increase the absolute power demand but reduce the indirect CO_2 emissions of power generation.

Looking at the future, a major reconfiguration of the production process might be needed due to the implementation of carbon capture and storage/utilisation technologies (CCSU). These are electricity-intensive technologies that if applied on an industrial scale while cause the power consumption of cement manufacturing to increase significantly, due to the capture and liquefaction process. Capture technologies, such as Oxyfuel as well as post-combustion technologies will require high power consumption for oxygen production in an air separation unit, the regeneration of absorbent agents, and the separation, purification, and compression of CO_2. Therefore, carbon capture would increase power consumption by 50 to 120% at the plant level.

Renewable power consumption

Cement process can correct the fluctuations in the management of energy supply by renewable sources avoiding the necessity of storage capacities for electrical energy.

Traditionally, cement producers coordinate their electrical power-intensive processes with local grid operators regarding the operating times and duration. Often this results in operating the raw and cement mills only temporarily at night (e.g. 8 of 24 h), when the energy demand and prices are lower.

On the cement plant's demand side, a flexible grinding approach could be used for raw meal production and cement manufacturing as power-intensive processes. The management of silo and production capacities could then be utilised similar to a battery and to make optimal use of excess renewable energy. A decrease in demand during periods of lack of electrical energy supply could decrease the need for power production from fossil fuels. The mills should be able to grind a maximum amount of material at times of abundant renewable energy so that the clinker production can continue without any stoppages.

The main drawbacks are a less efficient use of the mill and silo capacities and that the forecasting period and the peak load times can be too short for a start-up of the mill and for continuous mill operation. An on-off operation of mills would increase energy losses, the wear of equipment, maintenance and some amounts of product with uncertain product quality.

On-site power generation in the cement industry

Mainly in emerging markets, some cement producers are investing in wind farms or solar plants in order to ensure the supply in case of grid instability and to directly use renewable energy for cement production, in particular for grinding units.

A common process is the production of electricity using the waste heat from the kiln system. Normally waste heat (kiln exhaust gas, bypass gas and/ or cooler exhaust air) is used for the drying of raw materials or other materials like coal and petcoke, or cement constituents. It can also be partially recovered to produce electricity through a heat recovery boiler and a turbine system. Depending on the chosen process (use of steam, ammonia, organic and kiln technology in total, between 8 and 22 $kWh/t_{clinker}$ or up to 16% of the power consumption of a cement plant can be produced by using these technologies without changes to the kiln operation.

Main constraints for the developments of these technologies are the investment costs and efficiency limited by a low-temperature level.

Future developments: electrification of the production process

Using electricity for heat input to cement production poses a considerable challenge because the production processes require temperatures up to 1450°C. There are no commercially available solutions so far, mainly due to a lack of a business case for their development. While there is no intrinsic technical obstacle, a key condition for future electrification for the heat production is that the electricity is 100% fossil free and at affordable price.

The possible technologies under study are:

- Plasma: Plasma is a fundamental state of matter that occurs when a gas is heated sufficient to form an ionised gas. Temperatures between 3000 and 5000ºC can be obtained. The concept of using plasma generators in a pre-heater, pre-calciner kiln is at present the main technology path
- Electrical flow heaters: heat is generated by running a current through a resistive element, which usually is protected by a shroud, and transferred to gas flow through high-velocity convection. Maximum gas outlet temperatures of 1100–1200°C are quoted.
- Microwave heating
- Resistive electrical heating
- Induction heating

In Sweden, Cementa, a local cement producer, and Vattenfall, the Swedish state-owned power company, run a joint project (CemZero) with the aim to check the technical feasibility to electrify the cement production process. Different technologies have been tested, to be verified in larger scale tests. The production costs of cement in an electrified process is highly increased compared to today's technology but could be competitive compared to other technology options for radical emission reductions.