Cement Production

Highlights

- **Processes and Technology Status –** The manufacture of cement is a two-phase process. Clinker is first produced in a kiln system from calcareous (limestone, chalk or marl) and argillaceous (clay or shale) materials, with addition, in some cases, of small amounts of corrective materials (sand, waste bauxite, iron ore). Various fossil fuels and waste fuels are used in this process to reach the reaction temperature of 1450 °C. Secondly, the clinker is ground with calcium sulphates and with industrial processes wastes such as blast furnace slag, limestone, natural pozzolana and industrial pozzolanic materials, e.g. fly ash, silica fume and burnt shale. 90-150 kWh/t cement are used in the process. Two basic types of clinker production processes exist, depending on the way the row materials are prepared before entering the kiln system: in the wet method, water is added to form a wet thick slurry whereas the dry process is based on drying the bulk materials to form a dry powdered meal. The choice of process depends on moisture content of the available raw material. When wet raw materials (moisture content over 20%) are available, the wet process can be preferred. However, in Europe, today's new cement plants are all based on the dry process as the wet process requires approximately 56 to 66% more energy. For dry processes, current state-of-the-art technologies are kiln systems with multistage cyclone preheaters and precalciner. Capacities of up to 15,000 tonnes clinker per day are achievable and unit consumption as low as 3.3 GJ/t clinker.
- **Costs –** Investment costs estimates differ depending on the source. According to the International Energy Agency [IEA, 3] building a new plant with a capacity of 1 million tonnes/annum of cement using the conventional dry processes with 5-stage preheater and precalciner costs €263 per tonne/annum (€ 2010). The investment cost increases to some €558/t if CO_2 emissions produced in the process are captured (and stored) using post-combustion technologies and to €327/t using oxy-combustion technologies. According to the European Cement Research Academy [ECRA, 2] new plants with capacities of 2, 1 and 0.5 million tonnes per year, using state-of-the-art technologies the unit investment costs is €130, €170 and €250 per tonne/annum respectively (€ 2007). Operation and maintenance (O&M) costs (including labour, power and fuel costs, but no deprecation) amount to €29/t for new, state-of-the-art plants and to €32/t for a typical existing plant with no CO2 capture. O&M costs are estimated to rise to €66 and €45/t for plants equipped with post-combustion CO2 capture oxy-combustion capture, respectively. O&M costs include fixed operating costs, fuel cost, electricity cost and other variable operating costs).
- **Potential & Barriers –** An important innovation in cement production technology relates to the use of CO_2 capture and storage (CCS) technologies to reduce the CO_2 emissions, with potential reduction of up to 95%. Post-combustion capture and oxy-combustion CO_2 capture are promising technology options, but none has been tested so far in industrial-scale cement plants. Full-scale CCS demonstration projects are expected between 2020 and 2030 and commercial deployment after 2030. It is estimated that between 10% and 43% of the global cement capacity could be equipped with CCS in 2050. Apart from CCS technology, no breakthrough technologies are expected to cause a significant changes of electricity and thermal energy consumption in cement production. Electricity demand could decline from the current average value of 110 kWh/t of cement (2006) to some 105 kWh/t cement in 2030. Thermal energy demand could decline from the current 3.38 GJ/t (2006) to 3.3 GJ/t clinker in 2030. However, if CCS technologies are implemented, specific thermal energy and power consumption could increase considerably. Assuming the CCS implementation in some 20% of the cement production capacity in 2030 and up to 40% in 2050, then power demand for cement plants would increase to 115-130 kWh/t cement in 2030 and to 115-145 kWh/t cement in 2050.

Process Overview – Cement is a solid material made of clinker, gypsum and other additives. It is mainly used to form concrete, a conglomerate of cement, water, fine sand and coarse aggregates, widely used for civil engineering constructions. Cement has a strong hydraulic binder power. Reacting with water it becomes a hard and durable material in a few days [1, 7, 8]. Global cement production has grown steadily from less than 200 million tonnes in 1950 to more than 2500 million tonnes in 2006. Today's growth is largely driven by rising production in emerging economies and developing countries, especially in Asia. In 2006, almost 70% of the world production was in Asia (47.4% in China, 6.2% in India, 2.7% in Japan, 13.2% in other Asian countries), about 13.4% in Europe and the remainder in Africa (4%), in the US (3.9%), and in other American countries (5.8%). The EU-27 produced about 268 million tonnes of cement in 360 installations, of which 268 produce both clinker and cement, 90 produce only cement and 2 produce only clinker [1]. ■

Cement Production – The manufacture of cement is a two-step process, notably, *clinker production* and *cement grinding*. **In the first step**, the raw materials are fed to the kiln system to produce clinker. Clinker consists of silicates, aluminates and ferrites of calcium obtained from the reduction of calcium, silica, alumina and iron oxides present in the raw materials. Clinker production starts with quarrying the main natural raw materials, typically limestone, chalk or marl (as a source of calcium carbonate) and clay, iron ore, sand or shale (as a source of silica, alumina and iron oxide). The raw materials is crushed, ground and mixed to obtained a homogenous blend, and then stored. Raw materials handling may be accomplished by modern and energy efficient dry processes or by traditional wet processes. The choice depends on the nature of the available raw

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