Cement Industry

Portland Cement

Cement is a very important building material which was first of all introduced in 1824 by *Joseph Aspidin*, a mason of Leeds, England. He found that when a strongly heated mixture of limestone and clay was mixed with water and allowed to stand, it hardened to a stone-like mass resembling *Portland rock* which is a famous building stone of England. His cement was the prototype of the present Portland Cement.

Portland cement has been defined as "the product obtained by pulverizing clinker consisting of hydraulic calcium silicates usually containing one or more forms of calcium sulphate as an interground addition." Hydraulic calcium silicates possess the ability to harden without drying or by reaction with atmospheric carbon dioxide thus differentiating them from inorganic binders such as plaster of paris.

Composition of Cement

An average composition of a good sample of cement is;

- *Lime (CaO)* *61,5%*
- *Silica (SiO_2)* *22.5%*
- *Alumina (Al_2O_3)* *7.5%*
- *Magnesia (MgO)* *2%*
- *Iron oxide (Fe_2O_3)* *2%*
- *Sulphur trioxide (SO_3)* *1% .*
- *Alkali (Na_2O, K_2O)* *1.5%*

Raw Materials

The following substances are used as raw materials for the manufacture of cement;

- **Lime stone.** It provides lime CaO, Marble, chalk and alkali wastes can also be used, since these also supply CaO.
- **Clay.** Clay supplies silica (Si02) and alumina (Al_2O_3) to the cement.
- **Gypsum.** It is found in very rich stones up to 95% purity. Its addition decreases the setting time of cement.
- **Other materials.** A wide variety of other minerals, salts, oxides are used, *e.g.,* Fe_2O_3, MgO, SO_3, Na_2O, K_2O, CO_2 and water.

Manufacture of Cement

The manufacture of cement consists of the following steps;

Treatment of Raw Materials

The raw materials are lime-stone and alumina which provide CaO and Al respectively. Generally huge deposits of these are present round the factory area. These are quarried and crushed separately in suitable machinery to a state of fine powder. There are two methods employed for this purpose.

(a) **Dry Process.** This process is employed when the raw materials viz. lime stone and clay are hard. In this process the lime stone is first broken into small pieces. It is then mixed with clay in the proper proportions and finally pulverised to a fineness that 90-95% passes through a 100 mesh sieve. The mixture is ma homogeneous to produce what is known as *raw meal.*

(b) **Wet Process**. This process is used when the raw materials viz. lime stone and clay are soft, the climate is fairly damp and the fuel is cheap. In this process, the lime stone is crushed to suitable size and the clay is washed with water in wash mills to remove foreign materials like flint. The powdered lime stone is then mixed with the clay paste in the proper proportions (lime stone 75%, clay 25%) and the mixture is finely ground and made homogeneous by means of a compressed air mixing arrangement. The resulting paste is known as *slurry.* The slurry contains about 40% water.

Burning of Raw Meal or Slurry

Raw meal or slurry prepared as above is introduced into the rotary kiln with the help of a screw conveyer. The rotary kiln consists of a long cylinder 6 to 8 feet in diameter and 100 to 250 feet in length. It is made of steel and is lined inside with fire bricks (Fig. 1). As the rotary kiln rotates, the charge slowly moves downwards due to the rotary motion of the kiln. Now the charge is heated by burning coal dust which enters at the lower end with the help of a blower. As the charge moves forward, it meets higher temperatures. When it reaches the lowest part of the kiln, the temperature is' about 1500°C which is the maximum temperature in the kiln. The charge takes 2-3 hours to over the journey in the kiln.

Reactions taking place in the kiln at various temperatures are:

(a) up to 100°C	Evaporation of free water.
(b) up to 500°C	Evolution of combined water from clay.
(c) 500°C to 800°C	Crystallization of amorphous dehydration products of clay.

(d) 900°C and above Evolution of CO_2 gas from the decomposition of $CaCO_3$.

$$CaCO_3 \xrightarrow{\triangle} CaO + CO_2\uparrow$$

(e) 900°C to 1200°C

$$2CaO + Al_2O_3 \longrightarrow Ca_2Al_2O_5$$

$$3CaO + SiO_2 \longrightarrow Ca_3SiO_5$$

(f) 1250°C to 1400°C Commencement of liquid formation and formation of cement components into clinkers.

The resulting product is known as cement clinker and as it comes out into the cooler it has the appearance of small greenish black or grey-coloured balls varying in size.

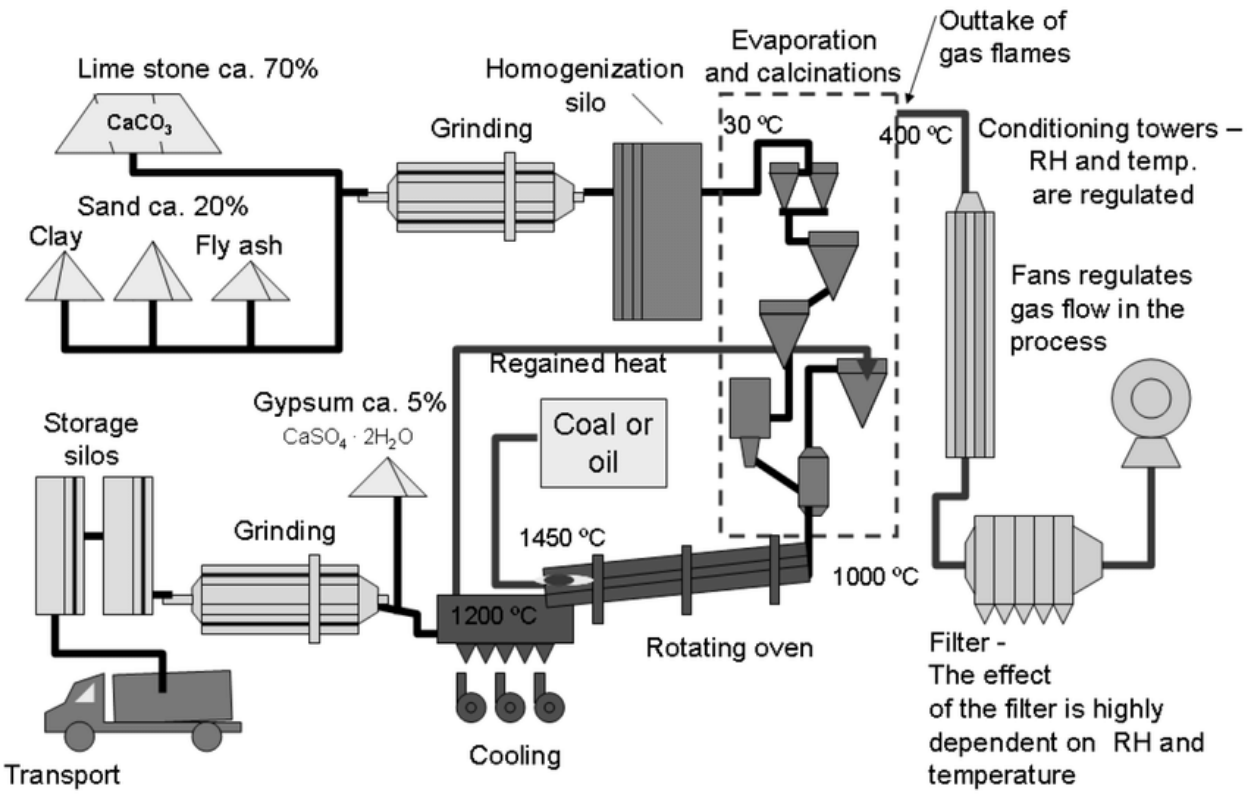

Fig 1. Flowsheet of Cement manufacturing

Mixing the Cement Clinker with Gypsum

The burnt clinker is then mixed with 5-6% gypsum ($CaSO_4.2H_2O$) to adjust solidification time in a ball mill. The ground material is sieved and packed in bags.

Setting of Cement

When cement is mixed with water, it absorbs water and the mass becomes hard and very resistant to pressure. This is known as the *setting of cement.* The cause of setting of cement is chiefly a hydration' process, followed by the decomposition of calcium silicate and calcium aluminate and formation of new compounds.

Setting Time

Cement has a unique property by virtue of which it combines with water and the resulting mass is very hard. The time in which cement sets is known as *initial setting time* and the 'time in which it hardens is known as *final setting time.* A paste of cement is made and placed on a glass plate. Vicat needle is then allowed to drop under its own weight. The needle will pierce the cement and touch the glass plate. After some time the needle will be stopped by cement slab and not reach the glass plate to touch. The time at which the needle is hindered by the cement slab is known as initial setting time, it should not be more than 45 minutes. The experiment is continued until cement hardens and it becomes difficult to take the needle out, this is called final setting time. For good quality cement, it should not be more than 10 hours.

Cement Industry in Pakistan

There are 23 cement units in the country with total installed capacity of 13029 thousand tonnes. Out of these 23 units, 4 units with installed .capacity of 1831 thousand tonnes are in public sector and 19.units having capacity of

11,198 thousand tonnes are in private sector. Province wise break-up in given below:

Province	**Units**	**Capacity (000 tonnes)**
Punjab	8	5343
Sindh	9	3441
KPK	5	3495
Baluchistan	1	750
Total	**2**	**313029**

The cement industry is the building block of the nation's construction industry. Few construction projects can take place without utilizing cement somewhere in the design. At present, there are 22 cement factories in Pakistan, 14 in the public sector and 8 in the private sector. The total annual installed capacity of these factories L 8.12 million tons. Cement Production in Pakistan averaged 2429.92 Thousands of Tonnes from 2003 until 2020, reaching an all time high of 4092 Thousands of Tonnes in October of 2019 and a record low of 864 Thousands of Tonnes in May of 2003.