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PORTLAND CEMENT

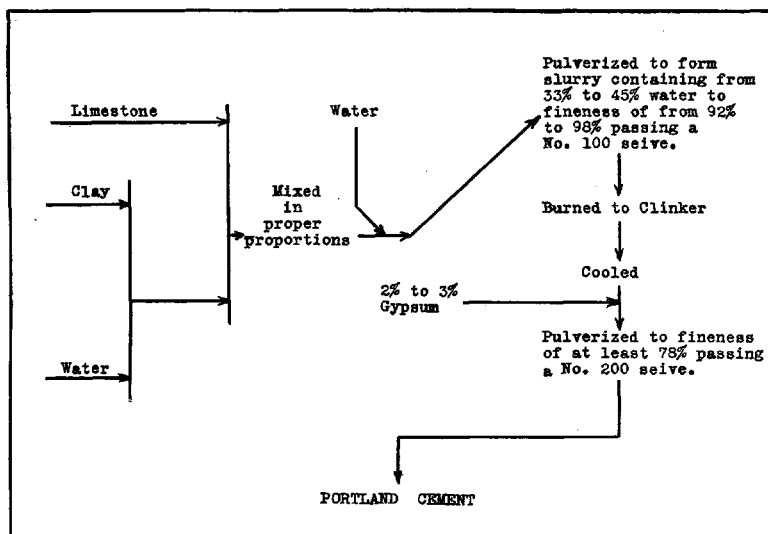
BRYCE O. REAY, *Arch'l Eng.*, '30.

THE manufacture of Portland Cement dates back to 1824, when it was first invented by Joseph Aspidin, a brick mason of Lewis, England. His product was so called because the resulting hardened cement was very similar in appearance to the natural oolitic limestone of Portland, England. Portland Cement is generally defined, however, as being a hydraulic cement consisting of compounds of silica, lime, and alumina. There are several natural earthen products which are used in certain combinations in the manufacture of this cement. Some of them are as follows:

- Limestone plus clay or shale.
- Chalk plus clay or shale.
- Marl plus clay or shale.
- Slag plus limestone.
- Alkali Waste plus clay.
- Cement rock plus limestone.

One or another of these combinations within certain proportional limits is burned to semifusion and the resulting clinker is ground finely to produce Portland Cement.

The most commonly used of these combinations is the limestone plus clay or shale. A modern method of producing cement from limestone plus clay will be discussed at present.



PRODUCTION DIAGRAM

THE RAW MATERIALS

For the purpose of Portland cement manufacture, only limestone of high calcium content can be considered. Other lime producing stone, such as dolomite and magnesites, which contain high percentages of magnesia, do not work well into the present standard methods of manufacture.

From the clay comes the silica and the alumina. Sometimes the clay is found in a locality very near to a limestone deposit and often it is even taken from the overburden that is removed from over the quarry. However, clays best suited to the purpose are sedimentary clays, because of their fineness and of their freedom from undesirable rocks and sands.

At this time several methods of securing limestone are being used. Open quarries are the most common but in some sections of the country, where the overburden is too great to permit of such a process, mining methods are used. Drills, dynamite, and steam shovels play the most important parts in the securing of the limestone from the quarry. Lumps of varied sizes are

locomotive to the crusher mills. The rock is loaded into side-dump cars and drawn by a small locomotive into a large crusher which reduces it to fist-like proportions. The crushed stone is then conveyed to the hammer mill, which continues the size reduction. Crushed to pieces, approximating the size of marbles or smaller, the stone is conveyed to raw storage bins. It is then drawn from the bins for use in the mill.

In the meantime another small locomotive is hauling clay to another raw storage bin. Taken from the storage it is sent through the wash mill. Water is mixed with the clay to form a thin muddy substance which is pumped up into large cylindrical clay storage tanks. There the clay remains until it is drawn off for use in connection with the crushed limestone.

COMBINATION TO THE FINISHED PRODUCT

Portland cement mills in this country fall into one of two general classes, "dry" plants and "wet" plants. At one time the dry process was taking the place of the wet process very rapidly but lately new inventions in the latter process have made it the most modern again.

The operation of the wet plant includes mixing and grinding the constituent materials in a wet state, this action producing "slurry." The crushed limestone and the wet clay together with a certain percentage of water are fed into the wet compeb mill. There it is ground by the action of large grinding balls. Inside of each wet mill are scoops which convey the coarsely ground slurry into another compartment of the mill, where it is ground more finely by the action of smaller balls or slugs. Thus the real slurry is produced. The new mix is then pumped into storage tanks. It is necessary to keep this slurry in the tanks agitated in order to prevent settling. To do this large paddles are kept in constant motion in each tank or compressed air is bubbled through the mixture from the bottom of the tanks. Some plants use a combination of these two methods.

From the slurry storage tanks the slurry is pumped as needed to the kilns. There are several types of kilns in use today, but the most modern and the one most widely used in this country is the rotary type kiln. One of these kilns in its usual form consists of a cylinder from six to

twelve feet in diameter and from sixty to two hundred fifty feet in length, made of sheet steel and lined with fire brick. This cylinder is supported at a very slight inclination (a few tenths of an inch to the foot) from the horizontal, on two or more steel tires or riding rings which encircle the shell and which in turn are supported on heavy friction rollers. The cylinder is driven at a speed of from one turn a minute to a turn in two minutes by a girth gear, situated usually near its upper end, and a train of gears. The power may be supplied from a motor or from a line shaft, but usually from the former. The upper end of the kiln projects into a brick flue which is surmounted by a brick lined stack.

The material to be burned is fed into the kiln in any regular manner through an inclined cast iron pipe, or by means of a water jacketed horizontal screw conveyer. The feeding device is usually attached to the driving shaft of the kiln so that when the kiln stops rotating the feed also stops. The material entering the kiln works its way through it, due to the rotation of the cylinder and the inclination, the time required to pass through the apparatus depending upon the speed of rotation and the inclination. The fully burned clinker drops from the lower end of the kiln.

The kiln is heated by a jet of burning fuel introduced at the lower end, the material traveling in the opposite direction from the flame and the product of combustion. Powdered coal is chiefly employed as a fuel for this purpose excepting in localities where the cost of fuel oil or natural gas is less. The temperature of the hottest part of the kiln is maintained around 2600 deg. F. It seldom becomes less than 2400 deg. F., nor greater than 2800 deg. F. The coal consumption varies from 80 lbs. to 150 lbs. per barrel of clinker, depending upon the length of the kiln, the heating value of the fuel, and various other manufacturing conditions.

On entering the kiln the slurry mixture is first dried, next the carbonates are decomposed and the sulphur and organic matters are burned away. When the hot mixture of lime, silica and alumina enters the clinkering zone, there are first produced some silicates and aluminates of lime which form most readily. These compounds are $5\text{CaO}\cdot 3\text{Al}_2\text{O}_3$ and $2\text{CaO}\cdot \text{SiO}_2$. These are probably formed in the order given, since the aluminate melts at a lower temperature than the silicate. Neglecting unessential elements we then have in the mix. $5\text{CaO}\cdot 3\text{Al}_2\text{O}_3$, $2\text{CaO}\cdot \text{SiO}_2$ and CaO . The first two compounds next unite in part with the third, lime, to form the calcium silicate and the tricalcium aluminate.

At the temperature obtained in the ordinary cement kiln, the compound $5\text{CaO}\cdot 3\text{Al}_2\text{O}_3$ will completely change to the compound $3\text{CaO}\cdot \text{Al}_2\text{O}_3$. The compound $2\text{CaO}\cdot \text{SiO}_2$, however, is not completely converted to the compound $3\text{CaO}\cdot \text{SiO}_2$ partly because there is not sufficient lime present to form the latter compound.

In summing up the important series of reactions to be affected in a kiln it is found that there are two: viz., the decomposition of the carbonates of lime and the magnesia into the oxides of these

two metals, and the recombination of these oxides with silica and alumina to form the three essential compounds of Portland cement—tricalcium silicate, tricalcium aluminate and dicalcium silicate.

Having been cooled the clinker is weighed and conveyed to a clinker storage. From there it is drawn to the dry compeb mills to be ground into the final product. As in the wet compeb mills either balls or slubs are used for the grinding. A degree of fineness, up to about 95%, is generally obtained in these grindings. More often, however, the fineness runs anywhere from 80% to 93%. At the time the clinker is ground the retarder is added. This retarder is gypsum and its function is to retard the set of the Portland cement when used in making concrete. It also adds slightly to the tensile strength of the cement. Gypsum rock is used in $\frac{1}{2}$ " sizes and is added in quantities up to 3 percent. The active retarding agent is the sulphur trioxide present in the gypsum. The addition of the retarder is usually done right before the clinker goes to the first mill in the clinker grinding department.

ARRIVAL AT STOCK HOUSE

Having been ground to the requisite fineness, the cement is conveyed to the stock house, where it is spouted or carried by conveyor into bins. When the cement arrives at this point it is usually tested, each bin being sampled. The samples are put through routine physical tests and, when the necessity arises, analyses are made. Inherent defects in the cement are quickly detected.

Portland cement is packed in bags weighing 94 pounds, four of these bags making a barrel weighing 376 pounds. The bags are of the valve type and are filled through a flap at the bottom by means of highly developed packing machinery. Portland cement is always furnished in a tied cloth bag or a sewed paper bag. The cloth bags are tied by machines before they are filled. By using these valve bags to pack cement in for shipment a crew of three men can pack and load in cars approximately 2000 bbl. of cement in one day. The loading is done by means of belt conveyors and trucks. The conveyor carries the sacked cement from the packing machinery into the car. It is then packed into each end of the car on trucks. Usually one man operates the packing machine and two men pack the cement back in the car. However, when faster operation is required and there are two packing machine available for the purpose two men operate the machines and three men are kept busy in the car loading and dumping the trucks.

Having been loaded to order the car is billed out to the customer and the Portland cement is made available for his use in a short time.

NAUGHTY

The meanest man in the world is the warden who puts a tack in the electric chair.

—*Kansas Engineer.*