Cement Industry*

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THE Cement Industry—or more correctly, the Portland Cement Industry—is among the foremost and most stable industries in India today. The capital employed in the industry is estimated to be over twenty-four crores of rupees and gives direct employment to nearly thirty-four thousand people. It is a nation-building industry which is rapidly and vigorously growing, and is closely associated with the social and economic progress of the country.

'Portland' Cement' is a synthetic building material of comparatively recent origin, having been invented in a form comparable to the modern product, by one Joseph Aspdin—a stonemason of Leeds, England, in the year 1824. Common hydraulic limes and cement, including natural cements annd puzzolonas of volcanic origin, which by the mere calcination and grinding of naturally occurring materials either alone or with lime, have been known for centuries past, even before the Romans.

The only difference between these cements and portland cement, lies in the selection and careful processing of the raw materials before the calcination takes place and in this sense portland cement may be considered a synthetic product.

The word 'PORTLAND' may be somewhat confusing. Today, 'Portland Cement' has a definite meaning in the engineering world; in the same manner as "Bessemer Steel," and bears no relation whatsoever to any particular company or country of origin. Even in Russia, I believe, it is understood as "Portland Cement." The name has stuck on as given by the original inventor, Joseph Aspdin, who found that the colour of the hydrated product resembled portland stone.

Portland cement is essentially a chemical industry in as much as during the process of its manufacture, the starting raw materials undergo a complete chemical transformation. A number of chemical compounds are synthesised during the transformation, and every step in the process involves chemical and/or physico-chemical reactions. The chemistry involved is so complex, and with new facts coming to light about the behaviour of cement, under a variety of conditions, the requirements of the constructional engineers are becoming so exacting; that portland cement is rapidly acquiring the status of almost a fine chemical. For, in the study of cement clinker, mineralogical and metallographic methods of examination, X-Ray structural analysis and examination of the structure by means of the electron microscope, have been applied. Let me assure you that these studies are not made merely for the sake of producing a research paper—but actually because these studies have become fundamental to the technology of the process of manufacture of cement, and for the understanding of its properties so that they could be utilised to the best possible advantage.

Portland Cement is, therefore, not a product, as is sometimes erroneously supposed, which is obtained by merely excavating naturally occurring rock and grinding it to a fine powder, with perhaps, a little baking on the way.

At the same time, the enormous

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quantities of limestone and earth which have to be excavated, handled and treated in giant crushers, pulverisers and roasters involving heavy mechanical equipment, entitles this industry to be described as a process-engineering industry in which mechanical engineering plays a major part.

Briefly, the process of manufacture of portland cement is as follows: —

Limestone (or any other calcium-bearing material, like chalk or marl or sea-shells) and clay (including shale and other residuary clays like laterites) are crushed and blended together by fine pulverising, in carefully determined proportions, and roasted at a high temperature — (about 1400 — 1500°C), by means of pulverised coal, or oil, a gas or coke breeze in rotary or stationary kilns; the resulting product known as "Clinker" is cooled, crushed and ground to an impalpable powder together with a little gypsum. The result is "Porland Cement"—the magic powder—and a building material 'Par-Excellence,' which like a true plastic can be pressed, cast or moulded for making solid or hollow blocks for a lowly dwelling, or poured in enormous quantities in the construction of a mighty dam, an air-strip or a highway.

There are three principal methods of manufacturing portland cement: the wet, the dry and the semi-dry.

By and large, in India, the wet process of manufacture is employed. In this 'wet' process the finely-ground and blended raw materials are brought to the condition of a fluid paste with the addition of water during grinding, after which they are processed through the rotary kilns for the necessary roasting and chemical transformation.

In the 'dry' process, the finely-ground raw materials are blended in the dry state and in the semi-dry process, the blended materials are nodulated with the minimum amount of water. Although the 'wet' process is somewhat more wasteful in fuel consumption than the other two types, the blending of the ingredients is much more thorough and, in consequence, the final product is uniform. At any rate, whichever process is employed, the final product must conform to exacting chemical and engineering specifications before it can be marketed as portland cement.

Here I may pause a little and review how like fashions in dress—especially those of the fair sex—the methods of manufacture of cement appear to be harking back to the way they started. The early manufacture of cement was in dry-process, intermittently working, vertical stationary kilns, much like the old pottery kilns. The quality and quantity of cement produced in such kilns was rather poor, but they had the advantage that they consumed comparatively little fuel. This gave place to the rotary kiln using the dry process which ensured continuity and better blending, but was inconvenient in other ways and this too, slowly, gave place to the wet process kiln where perfect blending of the raw materials was obtained by grinding them in the wet state. Quality and continuity of production were thus ensured but the process as already described was wasteful in fuel, as large quantities of water, which were added merely for the purpose of blending had to be evaporated and driven off. The rotary kiln has been for a long time a standard unit for cement burning, and from the 60 ft. kiln of the early times producing only about 35 tons a day, it began to be better and larger, with the modern kilns of over 500 ft. long and with 700 tons per day production. In the wet-process kilns, various heat-saving devices were introduced from time to time as fuel began to be more and more expensive. The existing conditions did not satisfy the cement technologist, and the semi-wet process of manufacture of cement came into being. The "Lepol" kiln is a typical example of this type of kiln. In a semi-wet process kiln, the raw materials were allowed to go into the kiln with only a small amount of water.

Serious consideration is now being given to go back again to the dry-process vertical-shaft kiln for clinker burning—with this difference—that the process is now made continuous much in the same way as a blast furnace for the manufacture of iron. There are a number of small plants working satisfactorily in Europe today on this principle. The advantages of this type of kiln are simplicity and very low capital cost. The earlier difficulties of blending dry powders have also been very largely overcome and the quality of cement produced has also considerably improved.

A distinct novelty in recent times in firing is the adaptation of a unit which has been used during the last 40 years for sintering and roasting metallurgical ores. In this, cement clinker is fired on a continuous travelling grate. I have seen such a plant operating in Germany and, in my opinion, this kiln constitutes a tremendous technological advance in the manufacture of cement clinker. The great advantage of burning clinker on the travelling grate is that the process allows coke breeze and low grade low-volatile fuels to be used.

There are three variations of portland cement for which Indian Standard Specifications have been written, and which can be obtained in India. These are known as ordinary, rapid hardening and low heat. Ordinary portland cement is used for normal constructional purposes, rapid hardening where high early strengths are required, and low heat where massive concrete work as in dams is involved, requiring a low heat of hydration during the setting and hardening of the concrete so as to prevent shrinkage cracks.

In the U.S.A., two more types of portland cement are on the market, which are designed to meet certain specific needs. A great many other kinds of cementitious materials which can be broadly classified as "Blended Cements" are also coming to the fore. These are controlled mixtures of portland cement with other ingredients such as granulated blast furnace slag, burnt shale or clay, fly ash etc., and have been evolved to satisfy fastidious customers or special conditions. All these types of cement are capable of being manufactured in India provided there is a reasonable demand for the same.

An interesting feature of the cement industry in India, is the diversity of raw materials used in producing normal portland cement. This diversity is as varied as the country's climatic and natural conditions which, in its turn, has resulted in the employment of special equipment and ingenuity in dealing with varied problems. For instance, the principal raw material, viz. limestone or calcium-bearing material used in the manufacture of cement varies from shells of marine biological origin and soft sedimentary deposits, to highly recrystallised metamorphic rock approximating to the hardness of granite.

It can be said without much hesitation that the size of the portland cement industry in a country reflects its industrial or social progress. Viewed from this angle, India has to travel a long way before it can be within measurable distances of the United States and of European countries. The following figures of *per capita* consumption of cement in India as compared with Industrial Nations of the West, give a revealing picture: USA—280 lbs., UK—260 lbs., Sweden—500 lbs., Belgium—500 lbs., Venezuela—80 lbs. and India—20 lbs.

Even in the new uses of cement in which its strength and durability are utilised to the full, we are lagging behind other countries, although the product manufactured is as good as any produced anywhere in the world. Such variations in its uses in concrete structures in the shape of light-weight concrete, shock and vibrated concrete, prestressed R.C.C. constructions etc., we have to make considerable leeway.

This industry which involves the winning and handling of thousands of tons of raw and finished materials, must have the highest degree of mechanisation. Here too, we fall short of American and Western standards as, by comparison with them, the number of man-hours employed in India in the cement industry is something staggering. Mechanisation not only reduces wasteful spending of human energy, but it is also a sure means of increasing the wages, and thus the standard of living, of the average worker. We have, however, a long way to travel before mechanisation in the true sense of the word can be achieved beause we do not at present manufacture any mechanical equipment such as excavators, compressors, diesel or petrol driven engines, etc. Mechanisation presuppose, therefore, a highly developed feeder industry. In spite of the low wages as compared with the standards, the cost of labour related to a unit of production is still high. This is, therefore, a challenge which the cement industry in India, like perhaps other industries as well, has to meet and overcome. In India, however, this challenge has yet anonther aspect. To what extent must one rationalise labour strength even if mechanisation were possible? We are 360 million poor people, and can we afford on artificial grounds to lay off people by introducing machines instead of men?

On the other side of the picture must be put the great strides which India has made in the manufacture of portland cement. *Considering that portland* cement in India made a real beginning only in 1912, with a tiny factory at Porbandar, with a production of 40,000 tons a year, today's production potential of over 3.5 million tons is not a mean achievement. By 1955-56 it is expected that the country may well exceed the productive capacity of 5.6 million tons per year. On the positive side of the picture too, it can be said that the cement industry in India has made more technical and engineering progress and gained more 'know-how' than almost any other industry.

Portland cement manufactured in India cannot only hold its own in the matter of quality, but also during the last few years there has been an impressive achievement in the matter of fabrication of some of the units of heavy mechanical equipment used in the industry. A fair idea of this effort can be gauged by the fact that until recently every single piece of equipment had to be imported from abroad, but now a large number of plant units like kilns, mills, crushers and conveying equipment is fabricated in this country and it can be said with confidence that this is not one of those activities which mushroomed during the stress of the war periods, to die a natural death thereafter.

It is pleasant to reflect too, what this growth and stability of the cement industry means to the general advancement of the country. More use of this nation-building commodity will directly result in the generation of greater hydro-electric power for industrial and other uses, harnessing of turbulent rivers to achieve gainful outlets in irrigation schemes, improved road communications, more and better houses etc. not to speak of the larger volume of employment activity in all the feeder industries like coal, jute, railways and so on.

To the gathering that has met here, *whose specialized studies lie in different* fields, the manufacture of portland cement may have some scope for each of you. To the colour chemist, there is the extremely interesting field of coloured cements (in fact one of your past students actually worked on the subject of coloured cements for his Master's degree). To the plastics man, the ability of cement to be moulded as a plastic into shapes or forms may be in the nature of a personal challenge. Perhaps today it is the other way round, for the field of plastics and new resins is growing so rapidly that we poor cementwallas are being threatened for some time that in houses of the future, cement will be ousted by plastics. At any rate, while we last, the plastic industry can help the cement industry in many ways. In the packing of cement for instance, I believe plastic liners for jute bags or paper bags are already a *fait-accompli*. The food and nutrition man can be thankful to the cement industry that cement plays such an important part in producing more food for the country by making it possible to dam turbulent rivers for irrigation purposes.

To the chemical engineer, the cement industry offers a tremendous challenge in various problems of drying, grinding, mass heat transfer, fuel economy and so on. For such of you who are academically-minded—and scoff at research which savours of commercial exploitation, there is the vast field of study ranging from the application of the phase rule equilibria in the glassy matrix of the clinkering compounds to metaphysical speculation about the true physical surface of fine powders and so on.

What Industry expects of the Technical Man*†

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I RECALL talking to a very good friend of mine who has long been a teacher of geology at one of our universities and a trainer of men and women in both classroom and field. I asked him to tell me what, in his experience, industry was most concerned with in looking for new employees. Without a moment's hesitation he replied : " Industry's interest, as evidenced by their questions, runs about in this order :

" 1. Is he a fellow that you would like to have around with you ?

2. Is he reliable ?

3. Has he good judgment and is he independent in his thinking ?

4. And finally, how well trained is he ? "

Very much along the same line, a head of an oil company exploration department replied as follows to the same question :

" What I expect a new employee to be, in order of preference, is :

" 1. Co-operative. Willing and ready to do what is asked of him.

2. Open-minded. Alert to listen to, and take advice from his superiors, and to give full consideration to all others.

3. Congenial. Able to get along with his fellow employees, but without lowering his own moral standards.

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