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CRI TECHNOLOGY DIGEST

NCB'S TECHNOLOGY FOR THE MANUFACTURE OF BURNT CLAY POZZOLANA FOR MAKING PORTLAND POZZOLANA CEMENT

National Council for Cement and Building Materials

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INTRODUCTION

MANUFACTURE of burnt clay pozzolana (BCP) of assured quality has assumed considerable importance in our country in view of its large scale use for the manufacture of portland pozzolana cement (PPC). In view of the advantageous properties of PPC, some of the major engineering structures in India, like dams, have used pozzolana, primarily BCP, and most of these projects had set up captive plants for the manufacture of quality pozzolana based on rotary kiln technology. However, there is apprehension in certain quarters about the quality of PPC produced/available in the country, since bulk of BCP used for manufacture of PPC is derived from brick kiln rejects and wastes and as such, is likely to be of poor and variable quality. It is, therefore, essential that BCP is manufactured using an appropriate technology and of quality capable of yielding good quality PPC. Quality of BCP is a function of chemico-mineralogical and physical characteristics of clays, the conditions of pyroprocessing and the process of manufacture.

This Technology Digest highlights the R&D work done by NCB on the evaluation of technologies for the manufacture of BCP and development of an appropriate technology for producing quality BCP at economic cost.

ESSENTIAL CHARACTERISTICS

Clays occur as mixed minerals, generally alumino-silicate hydrates, containing mainly SiO_2, Al_2O_3, Fe_2O_3 alkalies and alkaline earth oxides like CaO and MgO. Chemico-mineralogical composition, plasticity, thermal behaviour and grinding characteristics after calcination are some of the important characteristics of clay having a bearing on the quality of pozzolana.

a) **Chemico-Mineralogical Composition**

There are three major types of clays, viz. Kaolinite, montomorillonite and illite. Typical chemical compositions of these clays are given below:

Constituents, %	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MgO	CaO	K_2O	Na_2O
Kaolinite	53·5	43·9	0·5	0·03	0·17	0·20	1·37	0·08
Montomorillonite	63·8	22·2	3·4	0·51	4·87	2·88	0·10	1·73
Illite	54·5	21·9	7·4	0·90	3·76	1·25	8·88	3·39

The maximum value of silica/alumina ratio is 2 in Kaolinite, whereas this ratio may be 3 or more in case of montomorillonitic and illitic clays. Pozzolanic reactivity of BCP is related to the total amount of silica, aluminium and iron, and to the amount of silica in glassy phase and the amount of free alkalies. Higher the content of these, better is the expected quality of pozzolana.

b) **Plasticity**

Plasticity of clay is important for deciding on the technology for manufacturing BCP. It permits clay to be formed into suitable shapes and sizes for firing, using various kiln systems.

The major clay types can be arranged in the following order of plasticity:

Montomorillonite$\gg$Illite$>$Kaolinite

c) **Pyroletic Behaviour**

All clays contain interlayer and interstitial water. In illite clays, the small amount of interlayer water present is lost when heated to ~100°C and the OH lattice water is lost between 500°- 600°C. Kaolinite contains no interlayer water between unit cell layers. When Kaolinite clay is heated it begins to lose OH structural water at 550°C. The loss of OH water in crystallised Kaolinite is accompanied by a fairly complete loss of structure, but in a well crystallised Kaolinite some structural remains persist until subjected to a higher temperature. In case of montomorillonite, considerable water is lost at low temperature of 130 - 160°C. This water is usually the interlayer water and on further heating the OH (lattice) is lost at 600°C. The clays on heating lose water creating voids in the clay minerals and at higher temperatures the structure collapses generating active sites. DTA curves of 3 major types of clays are given in Fig 1A and 1B. It is clear from the Fig that the appropriate temperature of calcination of the three mineral types, that is montomorillonite, Kaolinite and illite are 600°- 800°C, 700°- 800°C and 900°- 1000°C, respectively. The order of reactivity on the basis of active site generation of the three clay types is as follows:

Montomorillonite > Illite > Kaolinite

However, since the clays occur as mixed minerals and generally contain appreciable quantities of quartz, the appropriate temperature of calcination is arrived at by firing the clays to different temperatures in the range of 600°- 950°C and determining the reactivity at given fineness. The optimum temperature of burning is presumed to be that at which the crystal structure of the clay mineral just collapses and the oxides of silicon, aluminium and iron are in active form. Further heating of the clay leads to crystallisation of the products and also formation of refractory compounds with much less reactivity.

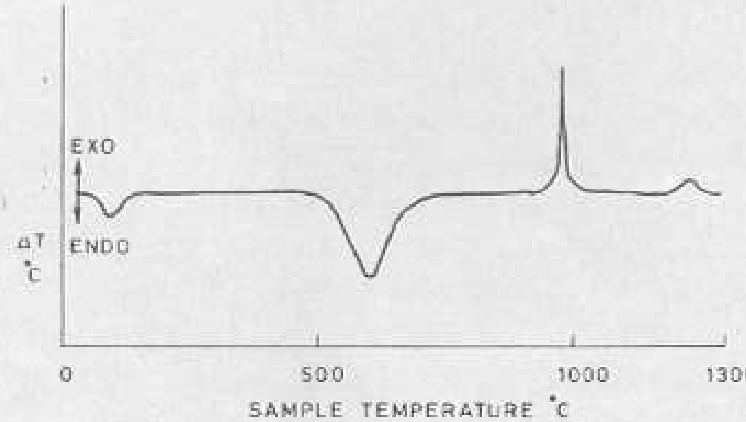

Fig 1A DTA curve for Kaolin Minerals

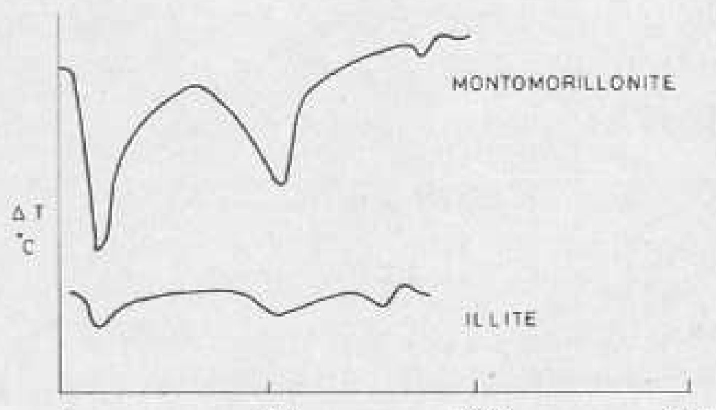

Fig 1B DTA curves for Montomorillonite and Illite Minerals

FINENESS OF BURNT CLAY POZZOLANA

The pyroprocessed clay is coarse and does not have sufficient reactivity to permit its use as pozzolana without further grinding. Grindability of BCP depends upon the chemico-mineralogical composition and the conditions of pyroprocessing. The clay containing high percentage of quartz produces BCP with relatively poor grindability. Hard burnt clay has high grindability index compared to soft burnt clay. To obtain desired level of reactivity, the BCP is ground to appropriate fineness. Indian Standard specification for calcined clay pozzolana (IS : 1344-1981) has specified two grades of pozzolana with minimum fineness of 250 m^2/kg and 320 m^2/kg respectively with a lime reactivity of 3 and 4 N/mm^2. Investigations carried out in NCB and elsewhere have established a definite correlation between Blaine's sufrace area and lime reactivity of pozzolana. It is therefore clear that the reactivity of BCP increases with increase in fineness of pozzolana and improve the engineering properties significantly.

PROCESS OF MANUFACTURE

Manufacture of BCP essentially involves winning of clay, preparing it for calcining, keeping the prepared burnt clay at suitable temperature for a minimum period to impart pozzolana properties, cooling it in a rotary cooler and grinding the cooled burnt clay to appropriate fineness. Depending upon the moisture content and the plasticity, clay can be prepared dry or semi-dry/semi-wet processes.

Three process technologies have been identified by NCB which are considered suitable for handling different types of clay:

i) Dry process for the manufacture of pozzolana from non-plastic clays,
ii) Dry process for the manufacture of pozzolana from dry/wet plastic clays, and
iii) Semi-wet process for the manufacture of pozzolana from plastic clays.

The upstream and downstream facilities have been worked out for the various process options. The processes essentially vary in the upstream facilities for the preparation of clays from the raw material to fine powder/nodules/bricks which can be fed to various kiln systems. The downstream facilities for all processes are generally identical. The process flowsheet for typical dry process is given in Fig 2.

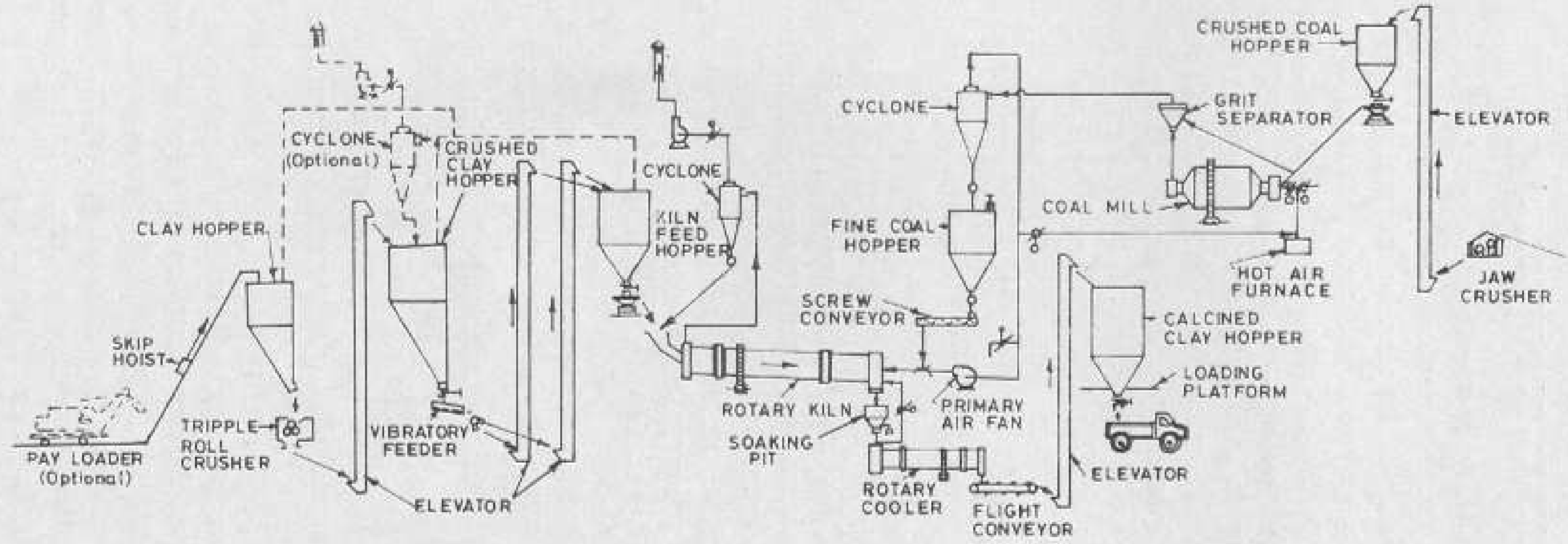

Fig 2 Dry process for the manufacture of Pozzolana from non-plastic dry clays

KILN SYSTEMS

Various kiln systems have been evaluated for manufacture of BCP and those considered suitable are:

a) Trench Kiln,

b) Down Draught Kiln,

c) Rotary Kiln, and

d) Fludised Bed Calciner

Of these, trench kiln is the simplest and oldest method for the manufacture of bricks. This technology though less capital-intensive, has a disadvantage that the temperature of burning cannot be controlled efficiently and the mode of calcination also produces a variability in burnt clay leading to relatively inferior quality of BCP.

Down draught kiln is suitable for firing of moulded bricks and extensively used for firing of heavy clay products. It has a better temperature control, compared to trench kilns, resulting in a better and more uniform quality of pozzolana. The fuel consumption is also lower than that of trench kiln because of better heat exchange systems employed.

Rotary kiln is used to produce pozzolana by burning the clay in the form of powder or nodules. Depending upon the clay characteristics, the upstream facilities for preparation of clays from their raw state to fine powder or nodules can be selected. This is the most versatile of technologies as it can use any type of clay. The process controls can be exercised with relative ease and precision leading to a uniform product of good quality.

ECONOMICS OF PRODUCTION

Production of quality BCP at economical cost is one of the basic requirements. The process technology and the scale of operations have a considerable bearing on the economics of production of BCP. The estimates of costs for the different kiln systems have been worked out by NCB and are summarised in the table below:

SL No	KILN SYSTEM	CAPACITY tpd	FIXED CAPITAL (Rs Lakh)	WORKING CAPITAL (Rs Lakh)	COST OF PRODUCTION (Rs/Tonne)
1.	Down draught kiln	50	18·57	1·27	95·65
2.	Trench kiln	100	14·27	1·51	52·70
3.	Trench kiln	300	39·02	4·41	50·42
4.	Rotary kiln	300	240·84	9·05	130·92

(Data based on 1985 estimates)

RECOMMENDATION ON TECHNOLOGY OF MANUFACTURE

It is evident from the foregoing that although cost of production of BCP using trench kiln and down draught kiln is relatively lower, the quality of pozzolana is not likely to be uniform. Rotary kiln technology though capital intensive and less economical is preferable because it produces uniform good quality pozzolana. The extra cost of production can be easily absorbed by the cement industry in manufacturing PPC using assured quality pozzolana as it would go a long way in improving consumer confidence in the product and also permit greater proportion of pozzolana to be used in the manufacture of PPC.

TECHNOLOGY TRANSFER BY NCB

NCB can provide industrial support in the field of establishing techno-economic feasibility of producing pozzolana from various siliceous materials like clay shale, etc, for the manufacture of PPC and lime pozzolana products, and undertake projects for preparing detailed project report for pozzolana plants of various capacities.

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