National Council for Cement and Building Materials

DRY BENEFICIATION OF MARGINAL GRADE LIMESTONES

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NCB TECHNOLOGY DIGEST

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INTRODUCTION

LIMESTONE is the basic raw material for cement manufacture. India, though is bestowed with vast reserves of limestone, however, many of the deposits are of marginal grade and warrant beneficiation before use. Moreover, the multifold expansion in cement industry and selective mining of high grade limestone, have also resulted in a sharp depletion of suitable quality limestone reserves making it imperative to use the available low and marginal grade limestone deposits.

A study by NCB reveals that about 38 percent of the existing cement plants are already facing the problem of inferior grade raw materials, characterised by high silica and/or magnesia contents.

A comparative study of national inventory of marginal grade *vis-a-vis* cement grade limestone prepared by NCB shows that the pattern of their distribution is similar. The zone-wise reserves are given in Table 1.

TABLE 1

Category of Reserves (in million tonnes)

Zone	Measured	Indicated	Inferred
North	257	1375	3074
South	1685	2003	12462
East	30	35	82
West	1385	557	2872
Total	3357	3970	18490

R&D WORK AT NCB

The various methods of beneficiation adopted in the Indian cement industry are: selective mining, manual sorting, wobbling, screening, and even flotation. Of late, these techniques are becoming ineffective either due to advancements in technology of cement manufacture like adoption of dry process or the recent trends in setting up larger capacity plants.

In order to perform beneficiation studies, typical samples of various types of limestones were collected and subjected to microscopic examination and physico-mechanical tests. Fig 1 shows some typical types of interlocking between calcite and waste minerals. It has been observed that minerals with sharp contacts and larger difference in hardness have easy liberation, as compared to irregular contact line. In the case of finer grain size and silica grains disseminated, it is, however, difficult to achieve adequate liberation. Moreover, in case of ternary locking the liberation is found more difficult.

A study of physico-mechanical characteristics, such as hardness, electrical conductivity and optical properties like reflectivity, etc, was found to be immensely useful for the identification of potential beneficiation techniques for different types of limestones. Based on the above characteristics, detailed experimental studies were carried out by NCB on :

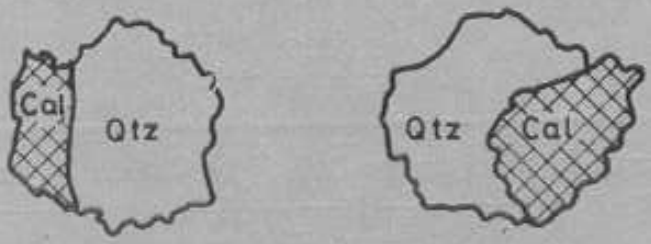
— Differential Grinding and Sieving (DGS)

— Electrostatic Separation (ESS)

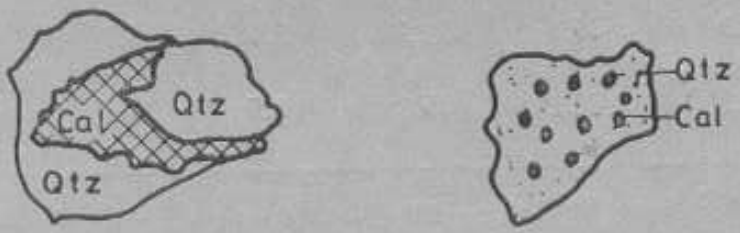
Differential Grinding and Sieving Method (DGS)

In certain types of limestones with silica in the form of quartz, it is found that due to variance of hardness between calcite and quartz, there is a difference in their particle sizes when they are subjected to comminution for certain period; calcite was ground faster and finer as compared to silica grains.

BINARY LOCKING



SIMPLE LOCKING



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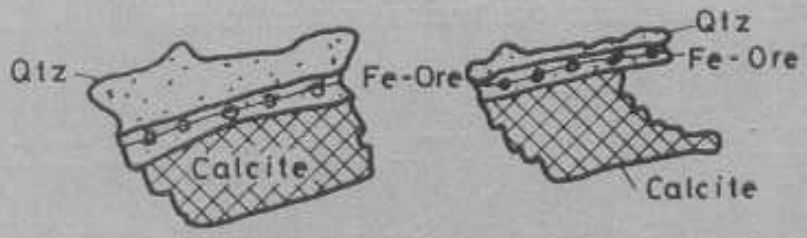
TERNARY LOCKING



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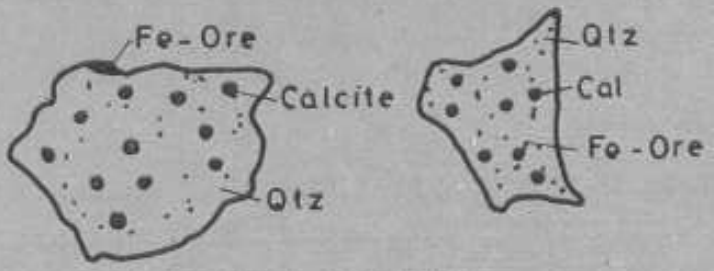

COMPLEX LOCKING

Fig 1

Such types of limestones when subjected to differential grinding and sieving for a particular residence time, provided a finer fraction of material abounding in calcite and coarser fraction rich in silica. For coarse grained limestones, size fractions generally below 300 microns showed enrichment in CaO. Typical results of the experiments are shown in Table 2.

TABLE 2

Sample No	Cummulative Recovery (%)	Quality CaO (%)			Quality SiO_2 (%)		
		Feed	*Concen.*	*Enrichment*	*Feed*	*Concen.*	*Reduction*
A	90	46.7	48.6	1.9	14.4	11.6	2.8
B	76	43.5	46.7	3.2	19.7	14.6	5.1

A model flowsheet for plant scale application of the process is shown in Fig 2. As can be seen therefrom, the application of this technique would not require much change in the original grinding mill flowsheet of the plant. Only incorporation of a set of vibrating screens in the coarse returns of the air separator together with the change in size of grinding media and their distribution may be required.

Electrostatic Separation Method (ESS)

This technique is in vogue for the beneficiation of heavy minerals from beach sands and placer deposits. It is based on the difference in electrical conductivities between various minerals in the ore feed.

Electrical resistivities of calcite and quartz are appreciably different to affect their separation. Ground limestone from raw mill, after separation of fines from air separator, flows through ESS equipment where conductors rich in calcite get separated from silica bearing materials. Results of experiments conducted in NCB on a few samples of limestone

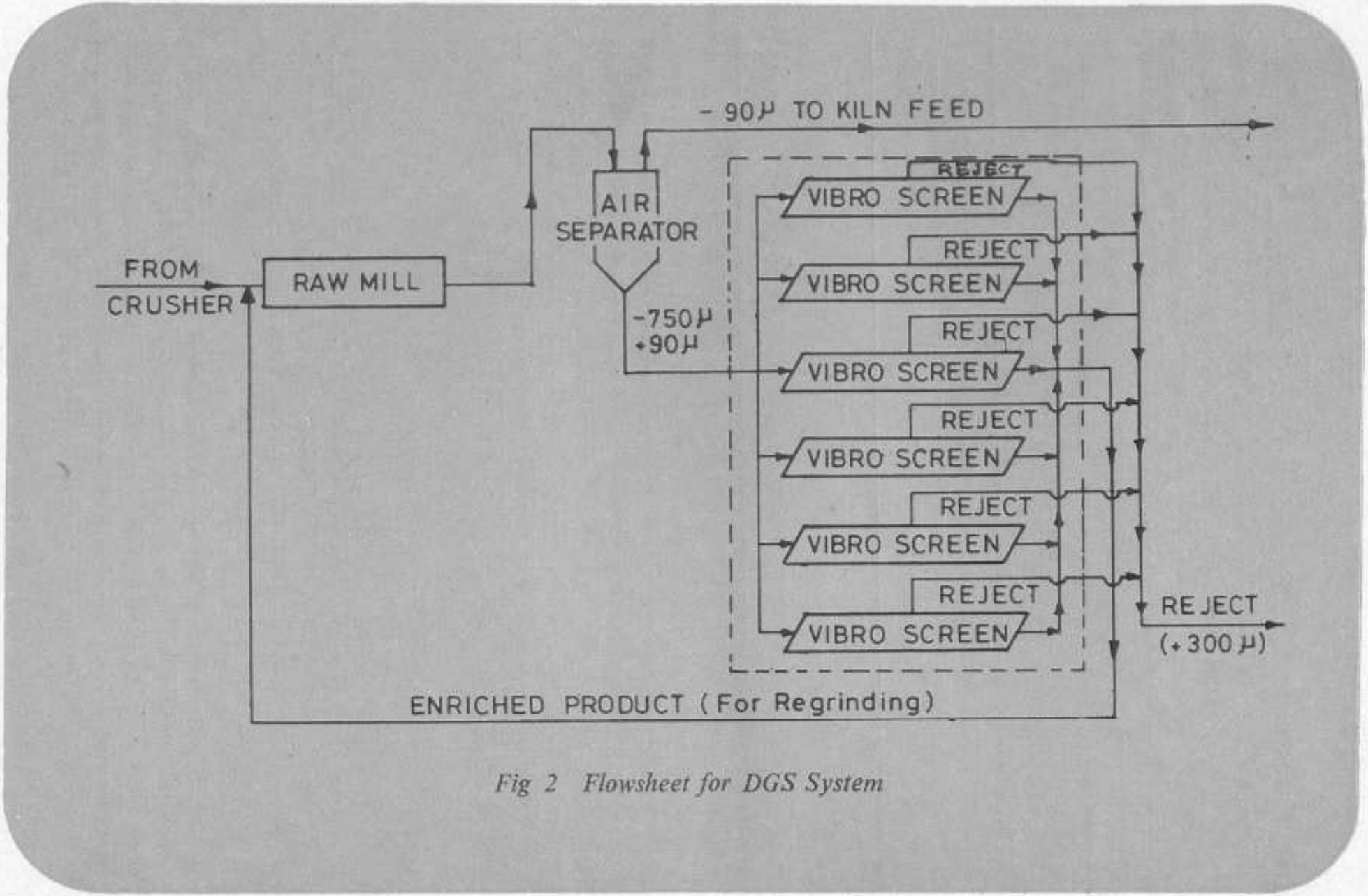

Fig 2 Flowsheet for DGS System

are given in Table 3. While the yield of the product ranged from 70 to 82 % depending on the extent of liberation, reduction in silica up to 8 % and enrichment in calcium up to 5 % could be achieved for one of the samples.

TABLE 3

Sample No	Cummulative Recovery (%)	Quality CaO (%)			Quality SiO2 (%)		
		Feed	*Concen.*	*Enrichment*	*Feed*	*Concen.*	*Reduction*
A	82.0	46.1	51.5	5.4	14.3	6.3	8.0
B	70.2	43.1	46.8	3.7	18.2	11.9	6.3

Techno-economics

A preliminary techno-economic assessment for the adoption of the above two beneficiation methods for a 1200 tpd cement plant presently using 20 % sweetner limestone purchased at a price of Rs 270/- per tonne, has indicated that with an additional investment of Rs 56 lakh for DGS method, and Rs 160 lakh for ESS method, the payback periods work out to be about one year and 6.5 years respectively. Though the initial investment and payback period appear attractive for DGS technique, ESS has the potential for more efficient enrichment and recovery. Hence the actual techno-economic evaluation, must be carried out on case to case basis.

PRELIMINARY STUDIES ON OTHER POTENTIAL TECHNIQUES

In addition to the above detailed investigations, NCB has also undertaken preliminary studies in respect of some of the other potential methods described below.

Photometric Sorting

This method is more or less a mechanised substitution of manual sorting. In this method, photomultipliers and electronic processors are used. The observed reflectance values are compared with the standard pre-recorded values of reflectance and separation of waste rock takes place by an appropriate valve located above the rock moving stream to

flush the air and deflect selected rocks out of their free falling velocity. The crushed limestone with size range 1200 to 12 mm can be treated by this method.

NCB in association with M/s Ore Sorters, USA, conducted preliminary studies on beneficiation of selective samples of Indian limestones by this technique. This technique has the potential to replace conventional hand picking method of beneficiation. Although the initial investment cost of the equipment is high, the operating cost is reported to be quite low and this technique may be useful for large capacity plants.

Bacterial Leaching

Bacterial leaching is an unconventional technique of beneficiation in which micro-organisms produce metabolic byproduct which activates the chelating effect on various minerals to dissolve unwanted waste rocks or minerals, and has high scope of utility in future.

NCB's preliminary R&D investigations on samples of marginal grade limestone show that though there is reduction of 4.7% in silica, the adoption of the method in its present status of the technology has prima-facie certain limitations, particularly because of 10% pulp density; the culturing of bacterial strain and leaching process require controlled ambient conditions.

NCB TECHNOLOGICAL SUPPORT

NCB renders technological assistance to the cement industry through evaluation of limestone for identification of potential beneficiation techniques, and conducting detailed experimental investigations of the above techniques, including techno-economics.

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