National Council for Cement and Building Materials

FLOW CONTROL DIAPHRAGM FOR BALL GRINDING MILLS

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NCB TECHNOLOGY DIGEST

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INTRODUCTION

SIZE reduction of solids is one of the major operations in a cement plant. It is estimated that nearly two-thirds of the total electrical energy consumed in a cement plant accounts for crushing and grinding operations. However, it is surprising that only 1% of this energy is gainfully utilised for comminution and the rest is wasted mainly in generating heat. Therefore, even a marginal improvement in this area can result in substantial savings in energy.

In cement plants most of the comminution takes place in ball grinding mills. The performance and the efficiency of the grinding operations depend on factors such as:

a) Appropriate mill circuit;

b) Optimum L/D ratio, chamber lengths and speed;

c) Design of diaphragm;

d) Proper selection of mill liners;

e) Proper mill ventilation;

f) Optimum grinding ball sizes and their distribution.

Energy utilisation in various compartments of a tube mill can be influenced by:

i) Optimisation of diaphragm design,

ii) Appropriate liner,

iii) Proper grinding media size and their distribution.

If any portion of the chamber is starved of feed material then the media in that area cannot do useful work. Instead, it will work on itself. Flooding of mill chambers is considered not a viable solution, as this can interfere with the media cascade, reducing the number of impacts and ultimately leading to complete overfilling. Even though optimisation of the liners, media size and media grading has been practised, enough attention has not been paid to optimisation of diaphragm design.

To obviate some of the inadequacies of the conventional diaphragms and for the optimum energy utilisation in mills, NCB has designed a simple, low cost, energy efficient partition diaphragm incorporating a unique flow control device placed between the diaphragm plates. This Technology Digest describes the salient features of the NCB designed flow control diaphragm for ball mills in the cement industry.

DIAPHRAGM AND ENERGY UTILISATION IN BALL MILLS

Primary objective of a diaphragm in a ball mill is to confine specific sizes of grinding media within a particular space and to maintain a level of product in the preceeding and succeeding chambers which will enable all the grinding charge to do useful work and control the size of the product passing through the diaphragm. Specific surface area of the material and energy utilisation along the grinding path in a two compartment closed circuit cement mill is shown in Fig 1. It shows that the energy utilisation in the coarse grinding chamber is low. One possibility of improving energy utilisation in the first chamber is by better adjustment of mass and size distribution of grinding media charge.

For efficient grinding and optimum energy utilisation, voids inbetween the balls should be filled up with the material. Material level in the chamber should be slightly higher than the grinding media level.

When using conventional double diaphragm with lifters, the material level in the grinding chamber becomes low and efficiency drops as the transport capacity of diaphragm is high. Use of dam rings and danula rings improves the grinding efficiency by increasing the residence time of material in different chambers.

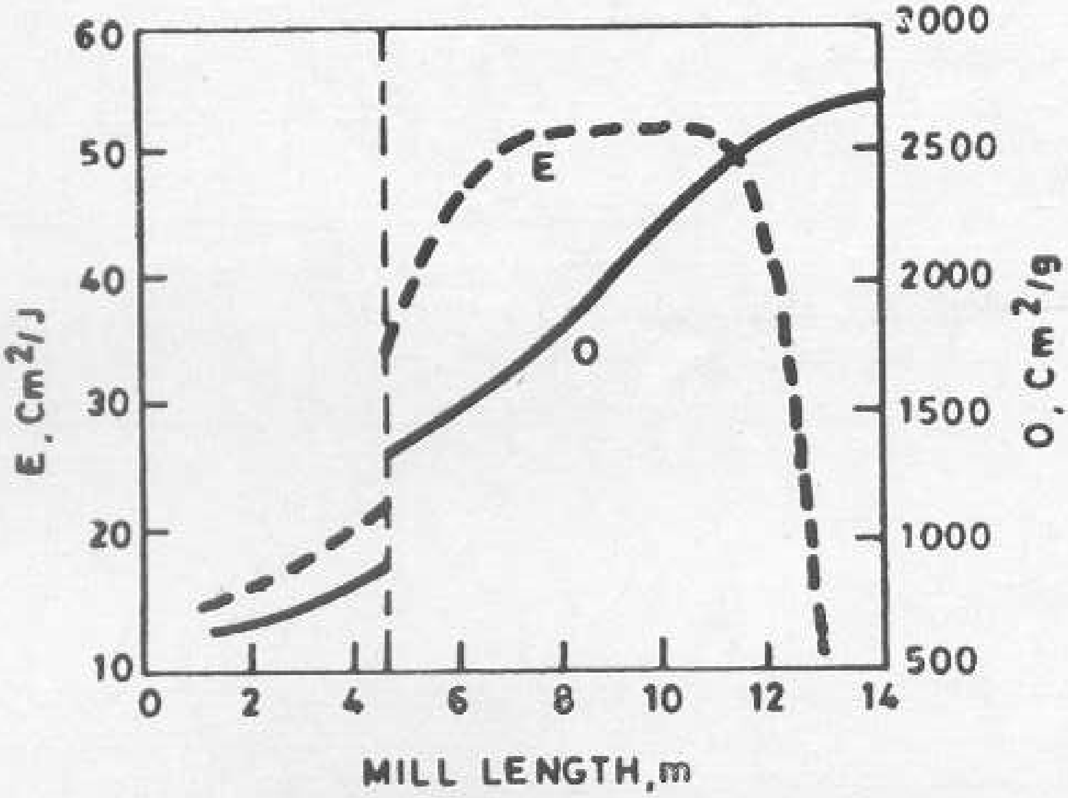


Fig 1 Energy utilisation (E) and product specific surface (O) along mill length

Further, by optimising the slot dimensions, it is possible to achieve the required material level in the mill chambers, but the pressure drop across the mill and air rate for coolings, limit the extent of reduction in slot sizes. Thus the need for an improved design of double diaphragm was felt for controlling material level in mill chambers without affecting other parameters.

NCB FLOW CONTROL DIAPHRAGM

With conventional diaphragm, material level sharply declines before the diaphragm due to fast scooping action. In this section, the grinding media cannot do useful work but instead works on liners resulting in increased wear and reduced energy utilisation. The objective of NCB Flow Control Diaphragm is, therefore, to improve energy utilisation by maintaining uniform level of material along the full length in each of the mill compartments.

The salient features of the NCB designed partition diaphragm (Fig 2) are:

1) The material retention time in the mill can be adjusted by forward curved lifters and flow control device in the diaphragm.

2) The flow control device comprises a combination of metallic plates through which the opening can be varied and adjusted as per the requirement, thereby controlling the material flow.

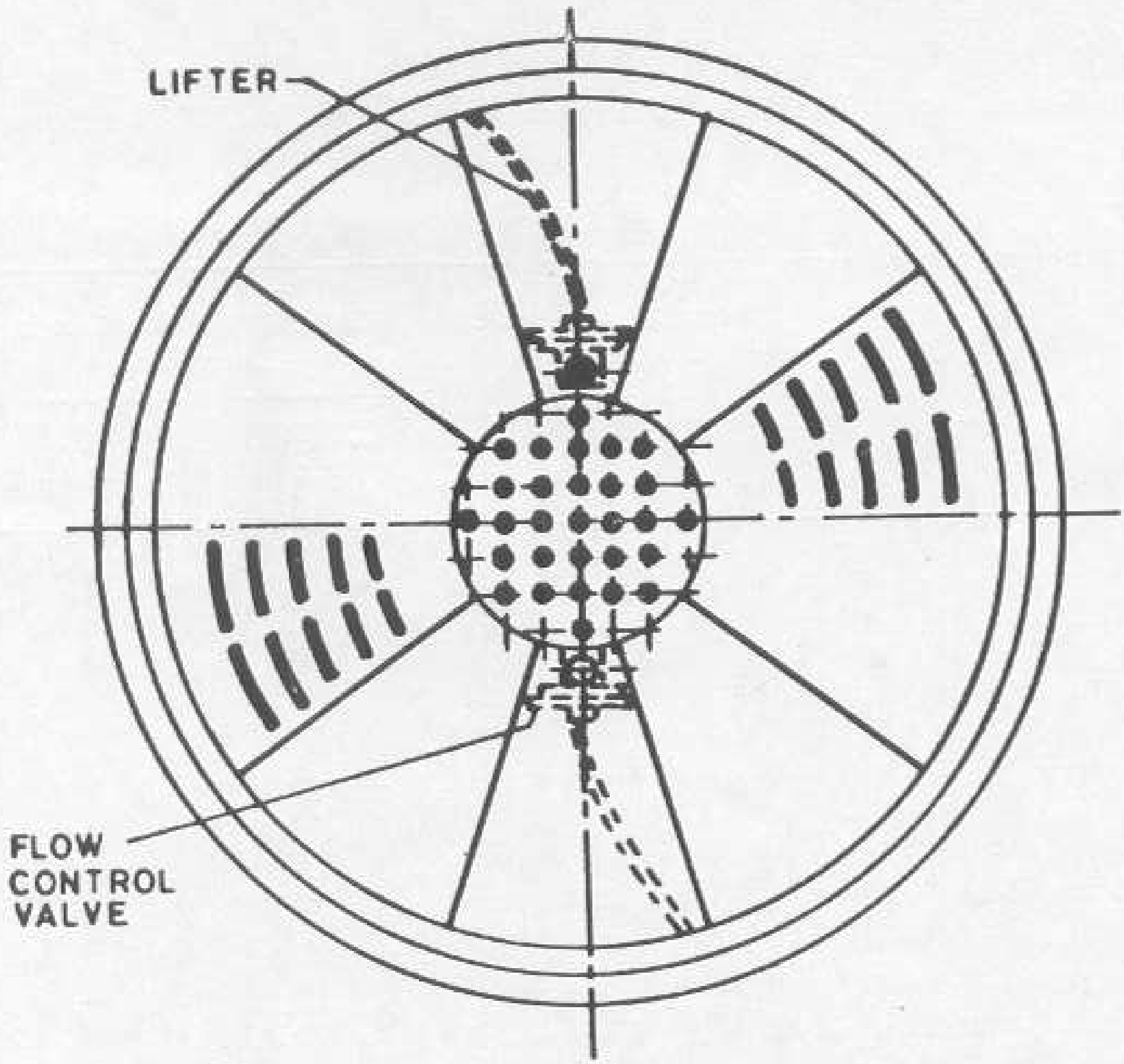


Fig 2 Flow control diaphragm

PERFORMANCE EVALUATION

To evaluate the performance of the NCB designed partition diaphragm, plant trials were conducted on a 7 tph cement mill. The flow control valve was initially kept fully open and feed rate was varied from 6 to 9 tph. Output Blaine value was constantly monitored. At the end the mill was crash-stopped and material level in the mill chambers was measured and size analysis carried out. The experiments were repeated at various valve openings from 30—100% and different output rates. The results are as given in Table 1.

TABLE 1

Mill System : 1.8 m dia × 9.6 m open circuit cement mill, 275 kW motor, 26.5 t media

Feed : Clinker 96%, Gypsum 4%

	With Conventional Diaphragm	With NCB Flow Control Diaphragm	
		50% FCV Opening	30% FCV Opening
Output (t/h)	7	8	9
Fineness, cm^2/g	3100	3100	3100
Connected load (kW)	275	275	275
Specific power (kWh/t)	39.3	34.4	30.6

The introduction of NCB flow control diaphragm resulted in the following benefits:

- About 28% increase in output compared to conventional diaphragm.
- Higher material holdup and uniform level in first chamber ensuring low wear of media and liners.
- Control of material residence time in first chamber with changes in feed size/quality.
- Cement with narrow particle size distribution, ie, less residue on 90 μm for same Blaine value as compared to conventional diaphragm.

Other Features

Grinding is effective with lower setting of flow control valve (*see* Fig 3). Control of material level in the first chamber of tube mill with flow control diaphragm is shown in Fig 4. Compared to conventional diaphragm, there is no material starvation at any place in the first chamber.

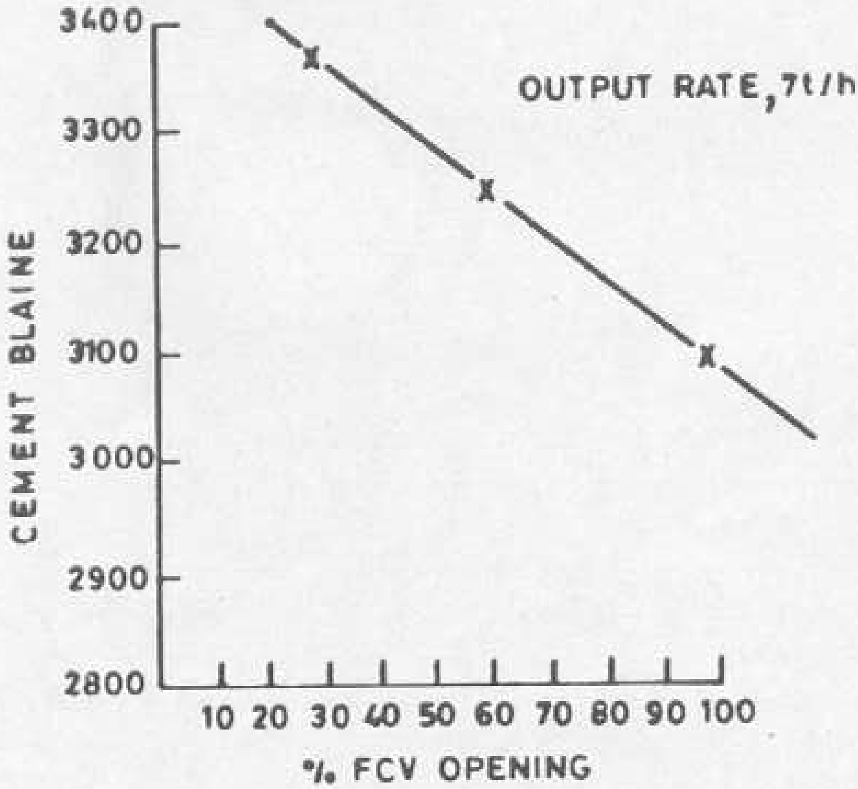
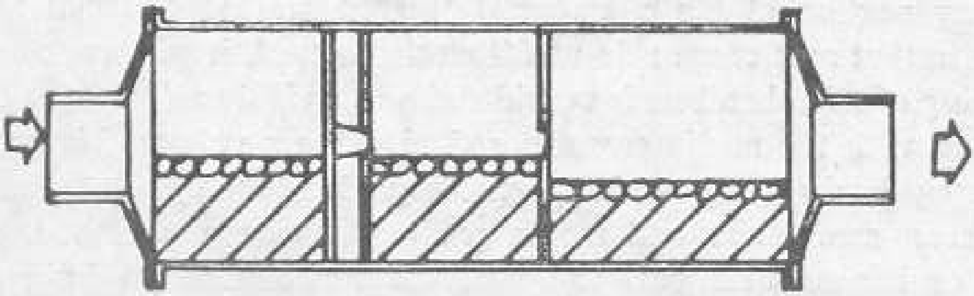


Fig 3 Variation of cement blaine with flow control valve setting



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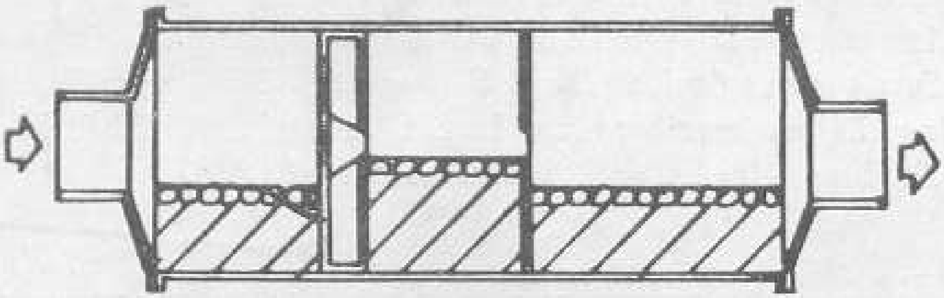

CONVENTIONAL DIAPHRAGM

Fig 4 Material level in mill chambers

INDUSTRIAL APPLICATION

Based on the performance of the NCB designed diaphragm in a 7 tph cement mill, detailed designs have also been worked out for higher capacity mills which are available for industrial applications to improve the grinding operations. NCB with its expertise in the area is in a position to assist the cement industry in designing, installation and commissioning of improved diaphragms for ball mills as well as optimisation of grinding mill operation.

Prepared by : S/Shri A Srihari Babu, S Giridhar Kumar and A Manna
Edited by : Shri S S Kalra

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