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Comparative Studies on Cylindrical and Conical Lime Shaft Kilns

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Cylindrical shaft and conically shaped kilns account for a major part of production of building lime in the country. The kilns charged with mixed feeds of limestone and fuel at the top are normally operated semi-continuously. Preliminary data were collected on some selected kilns and the comparative investigations were carried out on the two prototype models set up in the laboratory. The kilns were fired under similar operating conditions. It is concluded that in spite of the lower initial costs of cylindrical kiln compared to conical kiln for similar construction materials the latter exhibits superior performance in respect of productivity, product quality and fuel consumption. The authors recommend that the design features of both the existing types of kilns should be amalgmated with a view to evolving a lime kiln of improved design.

INTRODUCTION

Lime kilns of different shapes and sizes are in vogue for the production of quick lime[1–5]. The semi-continuous conically shaped (Rajasthan type) and the cylindrical shaft kilns, commonly employed by the building industry, are usually charged with mixed feeds of limestone and coal and are operated semi-continuously. Some design and performance data on these two kilns are reported for the individual types but the comparative data for the two shapes are not available.[1,5–9]. In view of this it was considered necessary to assess the comparative performance of these kilns under similar operating conditions for evolving improved designs for effective utilization by the industry.

EXPERIMENTATION

Figs 1 and 2 represents the prototype models for the cylindrical and conical kilns respectively. These low capacity kiln set-ups in the laboratory were built in brick masonry. The cylindrical kiln has a uniform inner diameter whereas the same decreases from top to bottom in a conical kiln. The limestone burnt in the two kilns was of building grade and the fuel used was steam coal grade having a gross heating value of 5 500 kcal/kg. The kilns were operated simultaneously both in batch and semi-continuous (Table 1) operations employing a predetermined optimum proportion of limestone to fuel for the conditions of the experiment. The kilns were provided with similar, chimneys at the top in order to facilitate the draft. A photograph of the experimental kilns is shown in Fig 3. Two discharge doors were provided in each kiln. The productivities of the two kilns were noted. At the end of the batch operation and during the progress of the continuous operation, product samples were collected and separated to estimate the distribution of the produce. From a knowledge of the quick lime obtained and the fuel consumed, the specific fuel consumption was determined. The operating temperature was observed by the chromel-alumel SS sheaths type thermocouples and consistent control was exercised throughout the duration of experimental runs.

TABLE 1 OPERATIONAL DATA FOR RAT TWO PROCESSES

	Batch	Semi-Continuous
Size of limestone	40-60 mm	40-60 mm
Size of coal	25-50 mm	25-50 mm
Pattern of charge	Mixed feed	Mixed feed
Limestone charge	340-350 kg	-
Coal charge	94-98 kg	-
Feed ratio of total charge		25-30 kg/hr
Limestone to coal ratio		3.5-3.7 (w/w)
Maximum temperatures	1020-1160°C	1020-1160°C
Overall batch times	18-20 hr	—
Kiln retention time	—	8-10 hr

RESULTS AND DISCUSSION

Comparative data on the distribution of product constituents by feeding a predetermined proportion of limestone and fuel as 3.6 by weight are indicated in Table 2 where quick lime denotes the soft burned lumps of lime and dust lime is the powdered fraction admixed with the ash content of coal. It it observed that the quality of the product, as evidenced by the degree of under-burning, is superior to the one obtained from the cylindrical kiln both in the batch and semi-continuous operation. The average productions based on three runs as obtained from the

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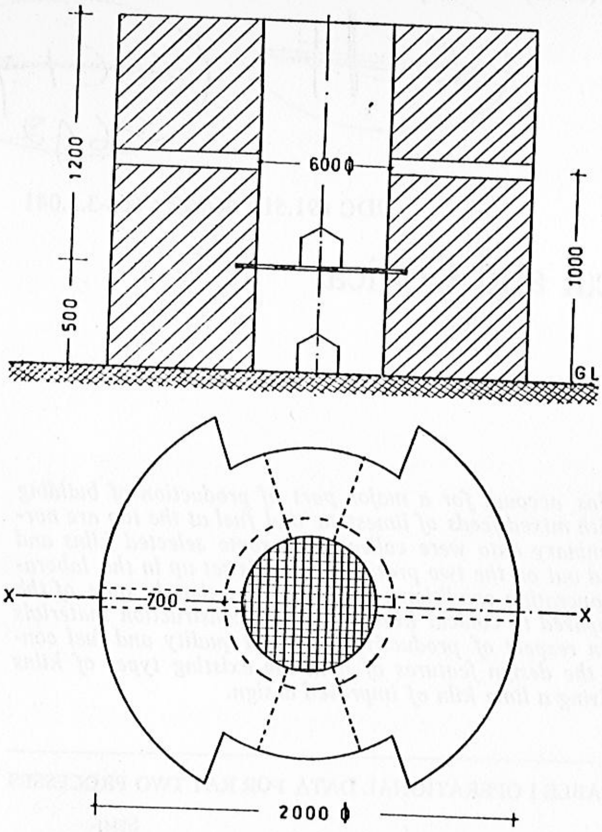

Fig 1 Details of prototype cylindrical shaft lime kiln

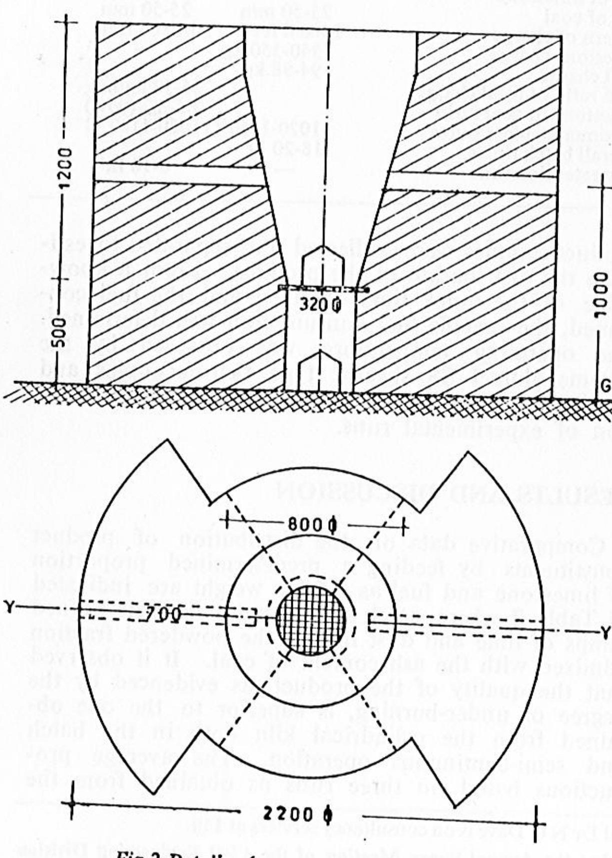

Fig 2 Details of prototype conical lime kiln

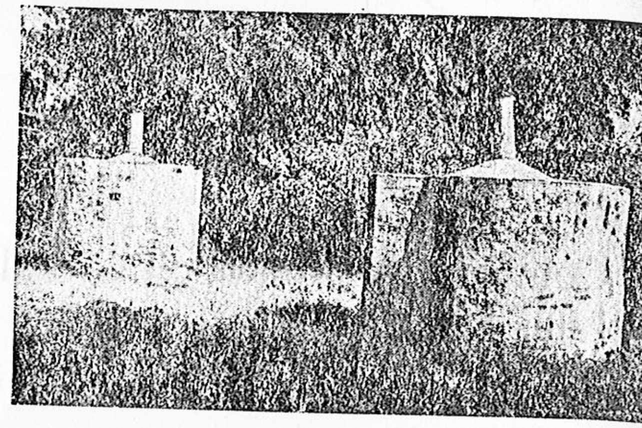

Fig 3 A view of the experimental lime kilns

prototype kilns by the semi-continuous operation (Table 3) show that higher yield of quick lime is obtained in conical kilns. The volumetric output is based on the unit volume of the respective kiln.

TABLE 2 RELATIVE DATA ON PRODUCT QUALITY

Product Constituent	Batch Operation		Continuous Operation	
	Conical	Cylindrical	Conical	Cylindrical
Quick Lime	51.3	48.2	66.3	63.8
Underburnt	16.3	25.1	6.9	11.1
Dust Lime	32.4	26.7	26.8	25.1

TABLE 3 COMPARATIVE OUTPUTS IN PROTOTYPE KILNS

Kiln Type	Average Production Rate, kg/hr	Volumetric Output, t/m³/d
Conical	11.7	1.04
Cylindrical	10.0	0.89

The energy consumed per kg of lime excluding underburnt and dust were compiled and the results (Table 4) show that for both types of operations thermal energy consumption in cylindrical kiln exceeds that in conical kiln. Similar trend has also been indicated earlier[6] in a survey of some running lime kilns wherein it was, however, inferred that for low capacity lime kilns the initial cost of the cylindrical kiln is 30-40% less than conical kiln.

TABLE 4 COMPARISON OF SPECIFIC ENERGY CONSUMPTION

Operating Method	Energy Consumption, kcal/kg lime	
	Conical Kiln	Cylindrical Kiln
Batch	3 690	4 000
Semi-continuous	3 410	3 540

The general drawbacks of the shaft kilns, that is wall effect, channelling, etc were reduced in conical shaped kilns on account of the uniformity of the draft as indicated by the lesser degree of under-burning of the limestone particles for this type of kiln. However, under the existing practice of operation where the fire zone is allowed to travel to the top of the kiln during the night hours, the conical kilns tend to exhibit poorer performance on account of the heavy heat losses from the surface area larger than cylindrical kiln[1].

CONCLUSIONS AND RECOMMENDATIONS

Extensive survey of the low capacity kilns[6] and the laboratory studies on the prototype models of these lime kilns have confirmed the comparative results of this paper. The conical type kiln performs better than the cylindrical kiln with respect to productivity, quality of the produce and thermal efficiency. Cylindrical kiln is, however, cheaper than conical kiln in so far as the initial cost is concerned. It was thus found feasible to amalgamate the design features of these two types to evolve an optimal design in respect of economy in cost and improved performance.

The burning zone and the cooling zone should be tapered downwards to accommodate the draft loss on account of evolution of gases in the burning zone and expansion of air in the cooling zone. The preheating zone should be tapered upwards to take into account the contraction of the gases because of the cooling effect caused by the preheating of limestone.

REFERENCES

1. N G Dave and I Masood. 'Studies of the Existing Lime Kilns in India'. *Proceedings of Seminar on 'Lime: Manufacture and Uses,'* New Delhi, 1972.

2. C L Verma and N B Saxena. 'Trends in the Design and Development of Lime Shaft Kilns'. *Chemical Concepts*, vol 5, no 9, 1978, p 23.

3. N Macedo. 'Factors in the Design and Economic Operation of a Lime Kiln'. *Proceedings Symposium on 'Manufacture and Use of Building Lime in India,'* Rewa (MP), 1958, p 47.

4. Mohan Rai and C S Sharma. 'A Study of Lime Industry in Dehradun'. *Indian Builder*, vol 14, no 11, 1966, p 20.

5. N G Dave, C L Verma, S P Mehrotra and A A Ansari. 'Some Recent Investigations on Design and Performance of Indian Lime Kilns'. *Consultation on Lime-Pozzolana, NBO*, New Delhi, 1977.

6. C L Verma and N B Saxena. 'A Performance Study of Some Low Capital Mixed-Feed Lime Kilns with Special Reference to Conical Kilns'. *Chemical Age of India*, vol 27, no 7, 1978, p 575.

7. C L Verma. 'Process Development and Design Optimization of Lime Kilns'. *Project Report, CBRI*, Roorkee, 1977.

8. F Sobek. 'Comparison Between Flameless Burning Process and Traditional Burning Methods'. *Masalah Bangunan*, vol 22, no 2, 1977, p 8.

9. R Spence. 'Lime and Surkhi Manufacture in India'. *Appropriate Technology*, vol 1, no 4, 1974-75, p 6.

DISCUSSIONS

D S Prakash Rao (*Member*)

I would like to seek a small clarification as a structural engineer. Was any law of similitude taken into account in designing the models for the laboratory study ? Or, was the volume alone taken as a criteria ? Is there any program to extend the studies to large scale kilns and make the studies more comprehensive ?

C L Verma (*Author*)

No, this work was taken up purely for assessing the comparative performance of the two designs based on approximately equal average inner diameters of the kilns and similar $\frac{L}{D}$ ratio. The kilns performed on similar natural draft due to chimney effect. A project has now been undertaken at the Central Building Research Institute, Roorkee, to extend the studies to large scale kilns also.

R S Mathur (*Fellow*)

I congratulate you for the paper. I only want to enquire whether studies have been carried out about geometrical shape of conical kilns giving optimum results. These could be standardized for various capacities of lime kilns.

C L Verma (*Author*)

Yes, studies have been carried out at the Central Building Research Institute about the geometrical shape of the conical kiln and the same has been standardized for the low capacity (less than 3 t lime per day) cinder fired mixed-feed kilns and coal fired shaft kilns for capacities upto 20 t lime per day.