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A high capacity steel shell lime shaft kiln for building industry

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The Indian building lime industry falls under the category of small and medium scale sector employing kilns of capacities generally upto 10 tpd. On account of the requirements of changed environment and some inherent drawbacks of the existing masonry kilns, a steel shell lime shaft kiln of 20 tpd capacity has been designed. The process engineering aspects and mechanical design features of the same have been detailed with due cognizance to pollution control measures. It is proposed that the existing low capacity country kilns may be replaced with this moderately high capacity kiln in congested and highly air polluting lime manufacturing centres in the country.

Lime is an industrial chemical of significant importance which finds extensive applications in a multitude of Building, Chemical Metallurgical and Allied process industries. It is produced by the endothermic process of calcination of lime stone, the heat being supplied by the combination of fuel, at elevated temperatures usually exceeding 900°C under atmospheric pressure conditions. The process is effected in a lime kiln. The various interphase and mass exchange phenomena vis-a-vis chemical reactions occurring inside a kiln are quite complex in nature and have to be understood properly for incorporating some controls on the kiln with a view to achieving fuel economy and uniform quality of product[1].

The Indian building lime industry, by and large, works in the small scale and cottage sectors. About 5 million tonnes of lime is being produced in India per annum out of which about 2 million tonnes are produced in the building industry. The units in the small and cottage sectors are distributed all over the country and the same can be seen outside the municipal, town, village limits in the proximity of habitation. Most of the units in the small-scale sector produce about 5-10 tonnes of lime per day.

Characteristics of Small Scale Lime Kilns

The low capacity kilns require less capital investment and working expenses. These kilns do not require sophisticated instruments and in most of the cases, even power is not needed. However, these kilns suffer from the following inherent drawbacks[2] :

(i) Low productivities
(ii) Low thermal efficiencies
(iii) No proper controls on the process
(iv) Poor quality of the end product
(v) Environmental pollution hazards
(vi) Reduced life span involving high maintenance costs

National Status

The improved vertical lime shaft kiln constructed in masonry and based on intermediate technology is rather a recent development in India and its use was earlier advocated by the Central Building Research Institute, Roorkee and Khadi and Village Industries Commission, Bombay for the manufacture of building lime for smaller capacities of production. Charging and discharging mechanisms are manual in the conventional lime shaft kilns[3].

Based on field surveys and detailed in investigations on typical lime kilns at several important lime manufacturing centres, the lime kilns for capacities of 5, 10 and 15 tonnes per day were designed at the Central Building Research Institute, Roorkee. Kilns of improved designs have been successfully installed and commissioned in different parts of the country. The salient features of the improved designs are as follows[4,5].

(i) Mixed-feed vertical masonry shaft (steam coal fired)
(ii) Cylindro-conical structure with uni-inner lining of fire bricks
(iii) Continuous operation – 2 to 3 shifts per day
(iv) Uniform natural draft
(v) Manual as well as mechanized charging
(vi) Fuel economy upto 15 per cent over conventional kilns
(vii) Suitable for dolomitic and calcitic limestones
(viii) Better quality of end product

(ix) Mild steel rings and angle iron outer facing for 5 tpd capacity kilns

(x) RCC ring beams and columns on the outer periphery of the 10 and 15 tpd capacity kilns

A low cost mechanical charging device to handle about 20 tonnes of material per day has been designed for feeding the mix of limestone and coal into the kiln. The labour requirement is reduced by 50 per cent while the total charging time is reduced by about 40 per cent[3].

Requirement of Steel Shell Kiln

There is a huge gap between the present production of lime and its likely demand. Although no reliable statistics are available, an annual short fall of as much as 7 to 8 million tonnes was envisaged during the eighth five year plan. The lime industry has felt the necessity of upgrading the kilns in order to increase production and bring them on more scientific footing. Thus the work on design and development of 20 tpd capacity steel shell lime shaft kiln was taken up at the Central Building Research Institute, Roorkee. The anticipated advantages of the steel shell structure over that of the masonry are as follows :

(i) Prolonged life and durability
(ii) Crack-free structure
(iii) Higher production capacities
(iv) Lower cost of production
(v) Thermally efficient
(vi) Amenable to mechanisation and instrumentation
(vii) Better provision for adoption of pollution abatement measures

Although the steel shell lime kiln technology has been developed at the Federal Republic of Germany, Switzerland, Japan, Italy, etc. yet the designs are either patented or proprietory in nature. Hence, the work was taken upto bridge the prevalent gaps in the field.

Process Engineering Design

Field studies on some of the existing high capacity lime kilns in sugar and steel industries were carried out for the collection of relevant design and performance data. Systematic studies on the effect of various process parameters on the design and performance of the lime kiln were carried out and results were utilized in fixing up the process engineering design features such as heights of the various zones and diameter of the lime kiln[1]. The thickness of the steel shell is calculated on the basis of the various types of loads and thermal stresses to be exerted on the kiln, keeping in view the permissible strength for mild steel shell.

Table 1—Specifications of the lime kiln

No.	Item	Specification
1	Shape	Double conical
2	Height	16.0 m
3	Average inner diameter	3.5 m
4	Construction material	M.S. sheet
5	Thickness of steel shell	10 mm
6	Thickness of fire bricks lining	23 cm
7	Thickneess of insulating bricks	11.5 cm
8	Limestone coal ratio by weight	5-6

Poke and observation holes are provided throughout the height of the kiln arranged at suitable intervals for effective operational control of the kiln. Brief technical specifications of the 20 tpd lime kiln are given in Table 1.

Mechanisation Aspects

Mechanical charging devices are used for hoisting the mixed-feed of limestone and coal to the top of the kiln. These devices may be continuous type of belt conveyor, bucket elevator, skip hoist, etc. as per site layout[3]. However, skip hoist has been considered to be the most appropriate system for the charging operation. The hoisting unit consists of a head assembly, made up of motorised reducer coupled to the winding drum through an electromagnetic brake. The raw materials are to be fed to the kiln top into a receiving hopper. For high lift and larger lumps of limestone, a skip hoist is considered more suitable. Bell and cone arrangement is proposed for feeding the raw material into the kiln. The bell can be lifted either manually or by a small motor. A central discharge arrangement is being envisaged for the withdrawal of lime. Figure 1 depicts the details of the steel shell lime shaft kiln. The bell and cone arrangement for feeding of the raw materials into the kiln is shown in Figure 2. The kiln is supported on four fabricated steel stands arranged to be placed on concrete foundation blocks. Five supporting rings are provided within the shell plate for sustaining the refractory lining (fire and insulation bricks) of different heat zones to enable renewal of the refractory lining of any zone without disturbing the others.

Provision for Pollution Control

Reduction in pollution of the environment is the crying need of the present times. Several governmental bodies, pollution control boards along with international environmental agencies have been advocating the employment of pollution control measures in various industries. Even though lime is a

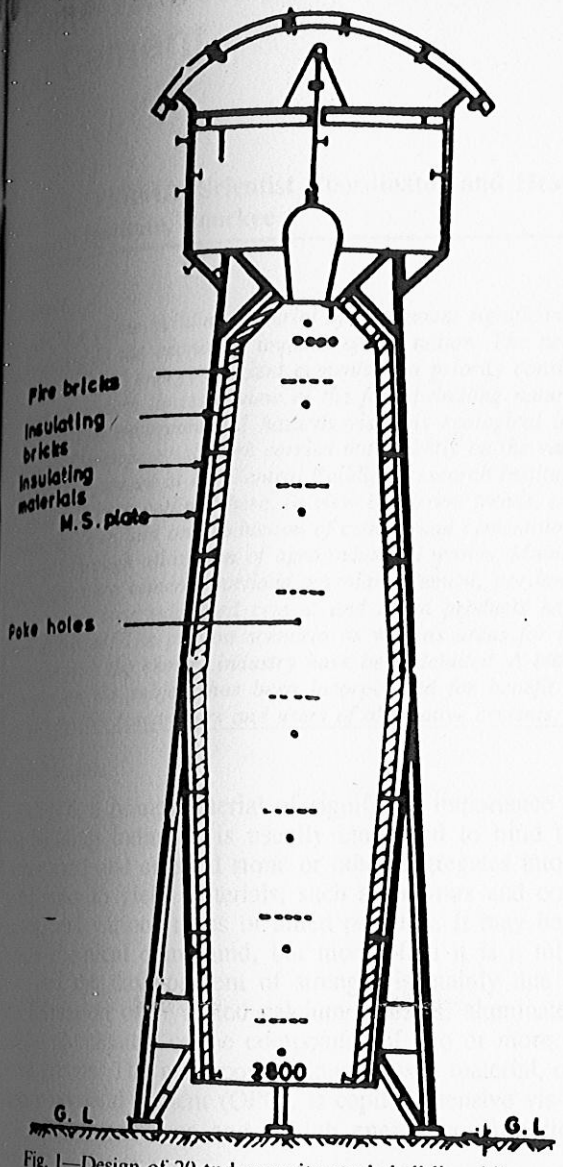

Fig. 1—Design of 20 tpd capacity steel shell lime kiln

low polluting industry yet suspended particulate matter (comprising kiln dust and hydrocarbon volatiles) has been identified to be the major pollutant being emitted from the coal fired lime kilns[6]. Out of the various pollution abatement devices, viz intertial separators, dry and wet scrubbing systems, fabric filters, electrostatic precipitators, etc. a water scrubbing system, chimney with hood along with an I.D. fan and a net work of piping, ducting, fittings, etc. has been designed and developed for the control of pollution from the lime shaft kiln. The control unit can be fixed at the top portion of the kiln and flue gases after purification can be discharged to the atmosphere through the chimney of the system.

Concluding Remarks

A coal fired steel shell lime shaft kiln of high capacity has been designed for prospective users of

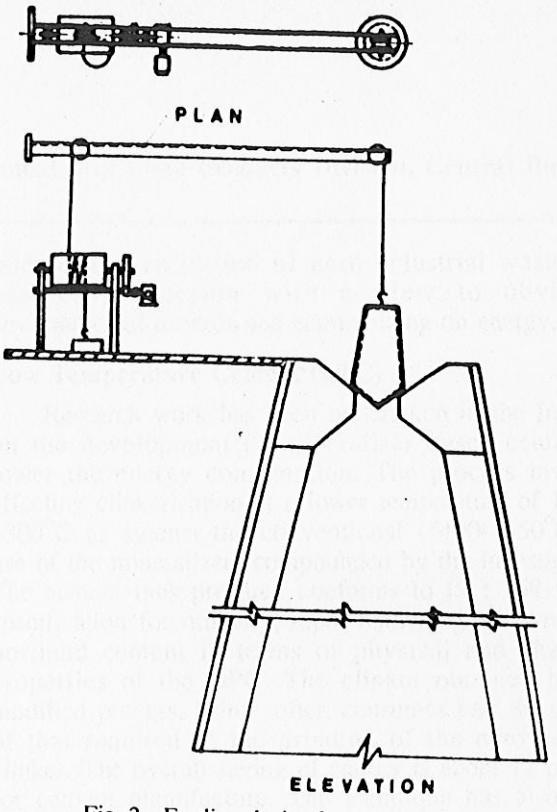

Fig. 2—Feeding device for shell lime kiln

the Indian building lime industry. The kiln is well equipped with semi-mechanization features and the same is also amenable to a fair degree of instrumentation, process vis-a-vis pollution control measures. The kiln is thermally efficient with low maintenance and operational costs. The installed cost of the kiln with all accessories is projected as Rs.15.00 lakh. It is envisaged to fulfil the requirements for calcination of high calcium as well as dolomitic limestones.

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