

Lime Kiln Design and Operation

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Lime Kiln Design

Historically the lime kilns" used in the domestic beet sugar industry have been, and still largely are, of the mixed feed, truncated, vertical shell type. The vertical shells, lined with fire brick, have for the most part followed two design patterns. One, the so-called "Belgian" type ("A," Figure 1) , is set up on columns with an open bottom some four or five feet above the operating floor, this lower opening having cross bars so arranged as to support the lime, permit the entrance of air for combustion of the fuel and also allow for drawing the burned lime as desired. In the other design, commonly called the "Kilby" type ("B," Figure 1) , the flared shell rests directly on the floor and the lime is drawn from doors placed in convenient working locations in the vertical sides around the base.

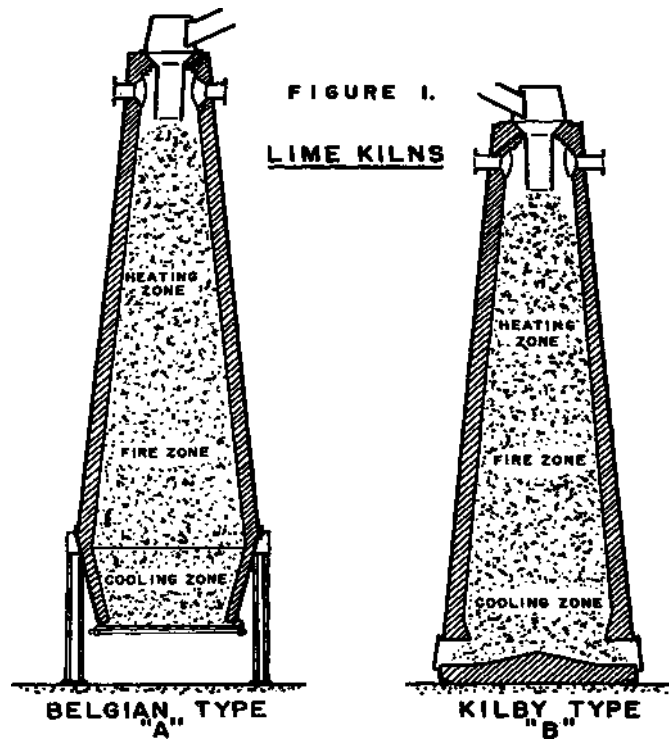
The kilns presently in use vary more or less in dimensions and cubical capacity, but follow a general pattern as to size. It is generally recognized that, if mixed feed kilns are too big, they become unwieldy and harder to control. For the most part the upper limit of capacity is accepted as about 4,000 cu. ft. for the burning of about 100 tons of rock per 24 hours. The lower limit is determined by the 24-hour tonnages required. Practical operating cycles vary from 36 to 48 hours.

Initially the charging apparatus and operating practice in both types of kiln were essentially the same. The coke and rock were placed together, in predetermined proportions, in a skip-hoist bucket and discharged into the kiln down a chute and through a large, straight, stationary cast iron funnel. The maximum size of the rock used was rarely reduced below 8 to 10 inches in cross section, and most of the stone less than 4 inches in size was discarded as waste. Coke consumption ran as high as 11 to 12 percent on rock and was rarely below 9 percent.

The results from operations under these conditions were far from satisfactory. A large percentage of the lime was either over or under burned and the fire conditions in the kilns were exceedingly erratic, often excessively hot both top and bottom at the same time and frequently causing severe damage to the kiln linings during the course of a campaign.

In due time, based on experience and observation, it became quite apparent that much of the difficulty in securing satisfactory kiln operation was caused by a distinct classification of the materials as charged, this classification being due, primarily, to the method of charging through a stationary central spout, coupled with wide variations in size of the pieces of charged material, which consisted of large and small pieces of coke, and large and small pieces of rock, with the pieces of rock predominantly larger than the pieces of coke. The classifying action due to variation in size of particles can be readily observed when such material as sand, gravel, coal, or even sugar, is built up into a conical pile. It will be immediately noted that there is a definite tendency for the larger pieces to roll to the outside of

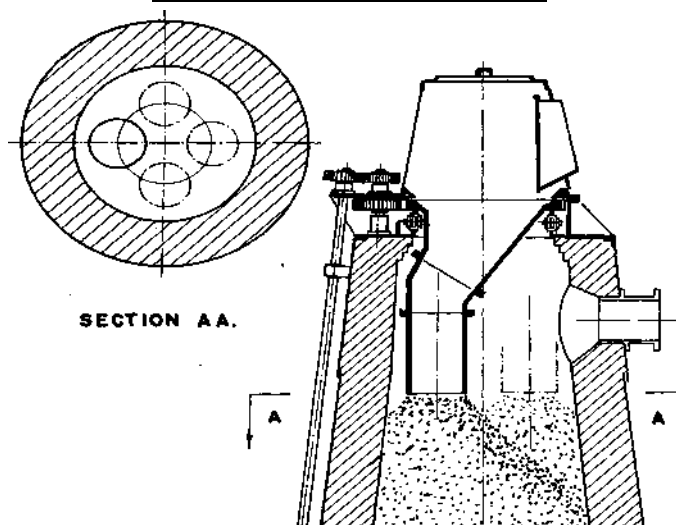
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the pile, while the finer pieces are localized toward the center. The greater the difference between the smallest and the largest pieces in the mixture, the greater this tendency toward segregation.

That this segregating action often takes place in kiln operations is evidenced by erratic kiln burning conditions. The coke, as noted, being uniformly in smaller pieces than the rock, together with the fines and dirt, if any, in the rock, tends to localize at the center or possibly towards one side of the kiln, with the result that in such localized areas there is an over abundance of fuel and, due to the choking action of the fines, a lack of sufficient air for combustion. By the same token, in other areas there is a reduced amount of fuel with an excessive amount of draft, the net result

FIGURE 2.
LIME KILNS
ROTARY EXCENTRIC CHARGING SPOUT

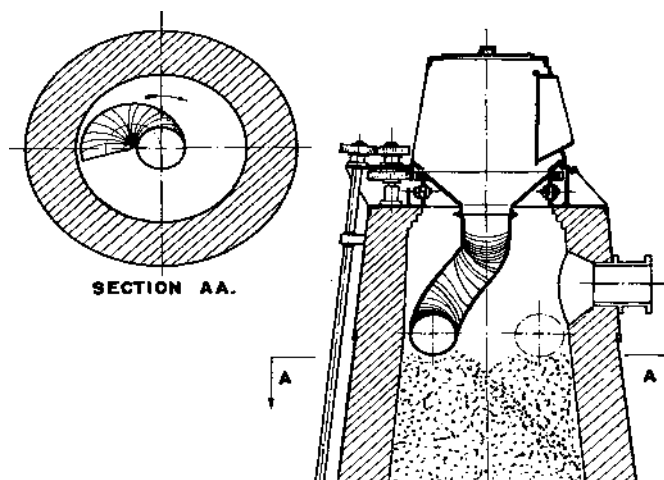


of this condition being that the fire climbs to the top in one section and remains persistently low in another section, the rock being under burned and over burned accordingly in these respective locations.

Having recognized that faulty distribution causes at least a large part of the difficulties in operation of mixed feed lime kilns, various changes in the design of charging spouts and apparatus have been made in an effort to improve this condition.

Given a predetermined percentage of coke and rock in the kiln feed, it appears logical to assume that if every piece of limestone was of the same size and composition as every other piece, and that if the coke pieces were all of uniform size and composition and were distributed uniformly so that there would be the same amount of fuel in each unit of cross section as in every other unit of cross section of the kiln, then both the heat required and the heat available would be completely uniform throughout the burning zone and the lime produced would be of a correspondingly uniform quality. Naturally, in practice such ideal conditions are impossible. Nevertheless this being the ideal goal, any progress, however modest, in this direction should show at least some beneficial results.

FIGURE 3.
LIME KILNS
ROTARY SPIRAL CHARGING SPOUT

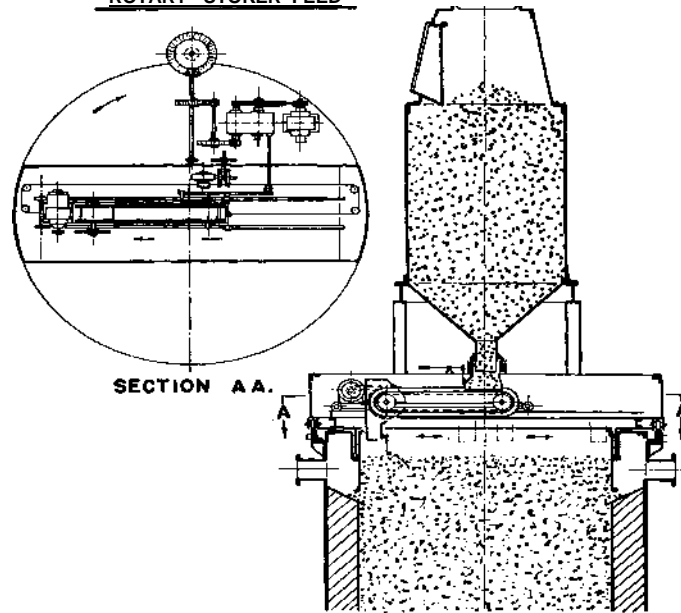


One of the first things tried was to reduce the rock to a more uniform size, this being done by reducing the maximum to about 5 inches in cross section. The larger pieces of coke were also broken up to prevent localized overheating due to concentration of fuel in the big lumps. This helped some, but still the results left much to be desired.

The next attempt at improvement was a series of modified charging spout designs, one being the offset rotary charging funnel (Figure 2). This funnel was designed to be turned more or less uniformly by a gear and hand wheel assembly, with each skip of rock. The improvement from this arrangement was quite definite. Instead of the rock and coke being piled up in a cone in the center of the kiln so that the larger rock rolled to the outside and the coke, which is usually much finer than the rock, being concentrated in the center, as per the action previously described, the material was spread somewhat more evenly around the circular cross section at the point of discharge. With the use of this offset rotary spout, coke requirements were reduced somewhat and lime quality improved. Many kilns at present are equipped with this type of charging apparatus.

Since even with the rotating offset spout the fire conditions in the kiln are far from uniform, the design in some cases has been modified in a

**FIGURE 4.
LIME KILNS
ROTARY STOKER FEED**

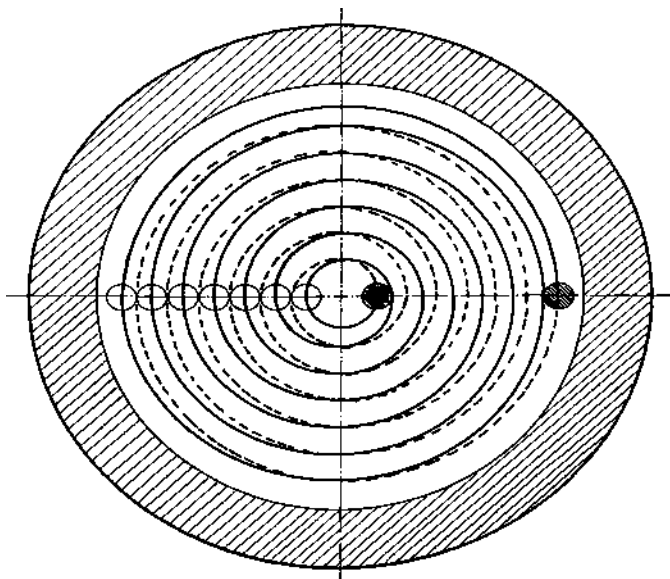


further attempt to improve distribution. This modified rotating design (Figure 3), which in shape has some of the characteristics of a spiral rams-horn, was aimed at further improvement in fuel distribution. It will be readily seen from observation of the action of the mixed feed as discharged from the skip to the chute into the top of the kiln that the coke, being lighter and finer than the rock, tends to lag behind and slide down the charging chute much slower than the heavier and larger pieces of limestone. The result of this lag, particularly with respect to the lower fraction of the fuel fines, with the straight offset funnel, is to concentrate an excessive amount of fuel on a circle traversed by that segment of the vertical portion of the charging spout nearest the center of the kiln, resulting again in an undue localized concentration of fuel. The spiral spout changes the angle so that the discharge takes place in a semi-horizontal manner somewhat tangentially to the circle of spout rotation. This carries the fines nearer the circumference of the kiln. The results of this modification are

somewhat better than with the straight offset charging spout; however, evidence of faulty distribution is still apparent.

A comparatively recent modification in the charging apparatus is quite a radical change from any of the previous arrangements. This latest design (Figure 4) is of a rotary stoker feed type. To accommodate this design the shape of the kiln shelf was changed from a truncated cone to a straight vertical cylinder having the same diameter top and bottom. The top, covering the entire cross section, is set on trunions and rotates at a uniform rate. On this rotating top is mounted an oscillating carriage supporting a pan conveyor over which is located a stationary hopper for receiving the rock and coke mixture from the conventional skip. The stationary hopper, being located over the vertical center line of the kiln, feeds onto a slowly moving pan conveyor which runs at a uniform rate and, within reasonably narrow limits, carries a uniform load of the mixed feed. As the kiln top rotates the pan conveyor with its carriage and discharge spout oscillates back and forth along the radius of the kiln top circle (Figure 5), such oscillations

FIGURE 5. LIME KILNS PATH OF ROTARY STOKER FEED SPOUT



being graduated by a variable pitch screw arrangement so that the amount of material deposited in each unit of cross section area is the same and the rock and coke, as charged, remain level across the horizontal kiln section. This design largely obviates the segregating action which takes place with a fixed or semi-fixed discharge spout design. In the operation of one such kiln charging installation coke consumption, over a number of years, has been consistently about 10 percent less than with other types of design and quality of lime produced has compared favorably with that produced elsewhere. Difficulty with clinkers has been practically eliminated.

Lime Kiln Operation

Irrespective of design, experience has shown that there are some basic principles of kiln operation which should be observed for reasonably uniform results. Gas pumps and/or exhaust fans when once set to the desired kiln capacity should not be changed as to volume of gas drawn from the kiln. When for any reason such change is necessary, the change, especially to increased volume, should be made gradually. A radical increase in air taken to and through the incandescent fuel in the burning zone obviously will increase the rate of combustion, with a consequent increase in temperature, which may result in serious clinkering. Slowing the rate of gas exhaustion without the addition of more fuel, which additional fuel cannot become effective until about half the kiln cycle time has elapsed, will result in incomplete burning of the rock.

Care should be exercised to keep the rock and coke charged to the kiln as free as possible from dirt and excessive fine material. The dirt acts as a flux, reducing the fusing temperature in the burning zone and increasing the danger of clinkering. The fines in general tend to clog the draft in localized sections and by the same token increase the draft velocity in other sections with additional danger of forming clinkers. Vibrating screens of suitable mesh opening on both rock and coke before the skip are desirable.

A word here may not be amiss as to the method of starting the kilns just prior to the beginning of the beet slicing operations. Excessive fuel, whether wood or coke, in the initial charge should be strictly avoided. If it is desired to have lime of a normal and satisfactory quality when starting up, then normal lime burning conditions must be established and maintained. This means normal time and temperature as they exist after operations are under way.

Naturally at the very start, since the kiln burden and kiln brick work are cold, running conditions cannot be exactly duplicated, but they can be approached. If the normal kiln cycle is 36 to 48 hours, then this time cycle indicates the time allowance before slicing of beets, when the kilns should be started. The fuel in the first one-third of the initial charge may be increased, possibly by as much as 50 percent above normal. The balance of the charge should carry the normal operating percentage of coke. If this is done, then the kiln draft, after the fuel in the first one-third of the charge has been largely consumed, can be set at the normal campaign operating rate. Normal fuel and normal draft should result in normal kiln temperatures in the effective burning zone, with resulting normal quality of lime.