METHOD OF CALCINING LIMESTONE

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References Cited

UNITED STATES PATENTS

2,603,471 7/1952 McDonald .......... 263/21 B

ABSTRACT

This invention is concerned with a continuous method of calcining limestone in a chamber having refractory walls and a refractory hearth movable through said chamber comprising the steps of depositing the limestone in a layer on the hearth, heating the limestone above 1600° F. as the hearth moves through chamber by directing burning gases against the surface of the layer and downwardly into the limestone and against the hearth, evacuating CO₂ and other gases released from the limestone and gas combustion from said chamber and removing the limestone from the hearth.

2 Claims, 3 Drawing Figures
METHOD OF CALCINING LIMESTONE

This invention relates to a method for calcining limestone to produce lime.
Calcination of limestone is the conversion of limestone CaCO₃ into lime CaO by heating the limestone to a temperature of at least 1600°F to disassociate the CO₂ therefrom, leaving the desired CaO.

Known methods for calcining limestone for the most part are based on the use of either vertical kilns, horizontal rotary kilns, or the movable hearth kiln.

In using vertical kilns, limestone is fed into the top of a vertically disposed refractory-lined shaft of substantial height. The shaft of the kiln may have various cross-sectional shapes as desired. As the limestone is calcined, by virtue of combustion attained through the use of gas or other suitable fuel, the limestone travels downwardly through the shaft, passing successively through a storage zone, a preheating zone, a burning zone, and finally through a cooling zone. The lime so produced may be drawn off from the bottom of the shaft in a continuous or in an intermittent manner.

Because a vertical kiln is charged at a single point normally on the vertical center line of the kiln, there is a tendency for larger sized stone to disperse towards the outer periphery of the kiln and for smaller pieces to travel down the center. As the products of combustion and gas of disassociation travel upwardly through the shaft, the non-uniform distribution of the charge creates unevenly distributed gas channels which in turn cause uneven distribution of the hot gases in respect to the limestone being calcined. Uneven heat distribution in turn is responsible for conditions which cause the kiln to “bridge” and “hang” either completely or partially. As a result of the foregoing conditions, the column of limestone will move downwardly in an uneven fashion, causing some pieces to pass through the burning zone faster than others. There is thus produced a calcined product which is of non-uniform character in that portions thereof are either overburned or undercalcined.

Because of the problems with respect to channelling and the resultant uneven fuel and air distribution, vertical kilns are usually confined to the calcination of limestone larger than 2 inches size which must be crushed to a marketable size range. This operation produces a large percentage of fines.

In the horizontal rotary kiln, limestone normally less than 2 inches is fed into one end of an elongated refractory lined tube which revolves continuously around its longitudinal axis which axis is tilted at a slight angle with respect to the horizontal. The tube is heated by gases. As the inclined tube rotates, the limestone is calcined and moves in a progressive manner to discharge at the lower outlet end of the tube.

A burning zone is arranged at the discharge end of the tube and combustion gases pass up the tube toward its charging end and thus approximate in their travel the burning and pre-heating zones found in the vertical kiln.

In the horizontal kiln the limestone is subject to rubbing action as between the stones themselves and the stones in abrasive contact with the walls of the kiln. Unless the stone supplied to the kiln has substantial resistance to abrasion and breakage, attrition will reach such proportions as to seriously lower the output of lime of desired size.

Besides the attrition mentioned above, it is found (1) that large stones proceed through the shaft faster than the small stones and also (2) that the small stones travel below the large and thus tend to be blanketed by the large pieces in the tube, so that for both of these reasons uneven burning occurs due to the varying effects of these factors, causing a product which is non-uniformly calcined.

With a view to overcoming the quality and process control problems of the vertical and horizontal kilns, a moving hearth type kiln of the type shown in U.S. Pat. No. 3,050,098 has been used. In this kiln limestone is fed onto the hearth of a rotary hearth type furnace and the hearth is rotated through a heating chamber until calcination is completed. The pieces are then removed from the hearth for transfer to a cooling chamber.

In the horizontal rotary kiln and the moving hearth type of kiln, the chamber employed for calcination is heated by means of fuel burners which fire into the space between the limestone charge and the refractory enclosure, and heat transfer to the limestone charge is mainly by direct radiation from the chamber. With this method of heating the CO₂ released by the limestone during disassociation remains essentially in a stratifiedblanketing layer of gas around the limestone. This gas is released at a temperature of approximately 1600°F, and exerts a cooling influence upon the bed of limestone. In the case of the moving hearth kiln, this cooling effect is sufficient to prevent the top surface of the hearth refractory from exceeding a temperature of 1700°F. Similarly SO₂ gas and other contaminant gases, present either as a constituent of the limestone charge or as a constituent of the fuel and which are of a high density, may also settle into the voids of the limestone bed and can, in fact, combine with the lime formed by disassociation.

It is an object of this invention to provide a method of calcining limestone that yields a high quality product at a fast rate of production.

With this invention, limestone is calcined in a chamber having refractory walls and a refractory hearth that is movable through the chamber, and the invention comprises the steps of depositing the limestone in a layer on the hearth, heating the limestone above 1600°F as the hearth moves through the chamber by directing burning gases against the surface of the layer of limestone and downwardly into the limestone and against the hearth, evacuating CO₂ and other gases released from the limestone and gas combustion from said chamber and removing the limestone from the hearth.

The invention will be clearly understood after reference to the following detailed specification read in conjunction with the drawings.

FIG. 1 is a plan view of a rotary hearth type kiln in which part of the roof has been cut away to show the chamber and the flame pattern on the limestone bed; FIG. 2 is a radial cross-section of the chamber taken at section 2—2 of FIG. 1; and FIG. 3 is a cross-section of the chamber taken at section 3—3 of FIG. 2.

Referring now to the attached drawings, my apparatus for calcining limestone consists of an annular refractory hearth 10 supported by a steel base 12 carried on wheels 14 which move on a circular base track 16. The hearth 10 is enclosed by a stationary annular
refractory chamber comprised of inner wall 18, outer wall 20, and roof 22 which are supported by steel framework 24, 26, and 28.

Raw limestone in a cold or preheated state is deposited on the hearth by the charging mechanism, generally indicated by numeral 30, and is carried through the kiln chamber as the hearth rotates in a counter-clockwise direction, calcined and discharged from the hearth by a discharge mechanism, generally referred to by the numeral 32.

The kiln has not been described in detail. It is generally speaking of the same type that is disclosed in U.S. Pat. No. 3,050,098 insofar as the rotating hearth, the feed means and the removal means are concerned.

It differs materially, however, in the manner in which the application of heat is provided because the method of calcining described herein is basically different to the method described in U.S. Pat. No. 3,050,098. In U.S. Pat. No. 3,050,098, as noted above, heat is transferred to a bed of limestone primarily by radiation, whereas, in accordance with the present invention, heat is transferred to a layer of limestone on the rotating hearth by directing burning gases against the surface of the limestone and downwardly into the limestone and against the hearth so that the burning takes place all around the limestone and subjects it to a rapid and intense heating to achieve an efficient calcination. The movement of the hot burning gases of the flame within the bed of limestone disperses CO₂ blanket created by the disassociation of the limestone. The evacuation of these gases, which are released at the relatively low temperature of 1600° F., greatly increases calcining efficiency because of the higher flame temperatures (in excess of 2400° F.) which surround the lime-stone pieces.

Heat is introduced to the chamber from the burners 34 located in the roof in the form of the open flames 36 which penetrate the limestone bed 1 right through to the hearth. Products of combustion from the flames as well as CO₂ released by disassociation of the limestone travel clockwise through the kiln chamber to flues 38 for removal from the film. These waste gases are carried from the flue to an exhaust fan and stack for discharge to atmosphere. A damper is provided in the waste gas duct to regulate the exhaust fan suction. Stone preheat equipment, combustion air preheat equipment and gas cleaning equipment can be installed in the waste gas system if desired and the exhaust fan size adjusted to suit the additional static pressure requirement. The basic rotary movable hearth kiln and its associated equipment (apart from the means for introducing heat to a bed of limestone) is well known in the art.

The burners 34 supplying heat to the kiln chamber are arranged in stations or zones for ease in controlling (a) flame length, (b) flame position, (c) chamber temperature. The factors which will dictate the exact number of zones and the number of burners per zone are (a) stone type, (b) degree of calcination required, (c) total kiln production, (d) whether charging preheated or non-preheated stone, and (e) the width of hearth employed. FIGS. 1, 2 and 3 show a kiln having 9 zones of burner control in which the last zone contains six burners and the others each contain four burners. The last or finishing zone serves a special function, in that the flames of this zone cover the whole width of the limestone charge in order to (a) act as a screen to prevent air infiltration from the discharge area, and (b) saturate the lime bed with flame of a reducing nature (deficiency of air) to prevent sulphur pickup by the lime if the fuel contains sulphur or if sulphur was present from some other source.

Burners are staggered transversely from zone to zone so that there is complete coverage of limestone with flame in each two adjacent zones. This division of heat input and burner position is desirable for four reasons: first, areas of lime-stone charge and hearth which are not directly in the path of the flame provide a continuous source of lower temperature into which heat can flow from those areas which are in the path of the flame, and thereby create a better condition for greater heat transfer from the flame than if the full width of hearth was in the path of the flame simultaneously. Secondly, means are provided for transferring products of combustion and CO₂ from disassociation through the kiln chamber to the flue area. The open areas between the flame provide an adequate path through which the gases can flow, and the area can be regulated so that the height of the chamber is proportional to the volume of gases in transit. Thirdly, the disposition of the flames of zones having four burners provides each and every flame with an open channel directly in front of it between the flames of the zone toward which the spent products of combustion of the flame must flow. This will help to avert a traditional fault of rotary hearth type furnaces, wherein kiln gases tend to follow the path of least resistance and travel to the inside wall of the annular chamber. Fourthly, the location and direction of the flames will tend to discourage the horizontal stratification of kiln gases flowing through the chamber without developing turbulent flow conditions and the related increase in pressure drop.

The velocity of the flames and the flame envelope at the point of contact with the flame and the limestone charge on the hearth is sufficient to insure that the flame will penetrate through the bed of limestone and come in contact with the refractory surface of the hearth which supports the limestone bed. The burners are specifically selected so that the flame from the burner is sufficiently long to accomplish this purpose and to have a splattering or boiling effect for some distance in front of the point where the flame first makes contact with the charge, which insures a large area of contact between the flame and charge. The combined effect of flame velocity and splattering will also serve to disturb the limestone bed in a manner which will insure penetration of the burning gases of the flame and prevent any stratification of gases within the limestone bed.

The burners in any one zone are connected to a common air supply 38 (which may be cold air or preheated air) and a common fuel supply 40, each of which are equipped with metering and flow control devices so that the chamber temperature within that zone can be automatically controlled by thermocouple 42, and a suitable control instrument. Each zone is controlled independently to provide the proper temperature in that zone for calcination of the limestone bed.
The individual burners in any one zone are sized so that the heat input from that burner in relation to the heat input from the complete zone is in like proportion to the quantity of stone heated by that burner in relation to the quantity of stone heated by the whole zone. In addition, the burners are designed so that the flame length and width may be adjusted without changing the heat input of the burner. The burners burn propane or any other suitable gaseous or liquid fuel.

The number of zones, burners per zone, length and width of flame, angle of incidence of flame to hearth, degree of flame penetration into limestone bed, temperature of individual zones and other aspects of the process and apparatus can be increased or decreased as required to suit the calcining requirements.

The calcination time for limestone pieces contained in a bed supported on a refractory hearth is reduced by a minimum of 50 percent by directing the flame into the bed of limestone and against the hearth as opposed to directing it into the atmosphere above the bed of limestone. This is a remarkable difference in calcinating efficiency. Moreover it has been found that the calcinating efficiency with this invention is not materially affected by the depth of the bed providing that the flame penetrates the bed to the refractory surface of the hearth. There is, for example, little difference in calcinating time between a bed depth of 4 1/2 inches and a bed depth of 3 inches for limestone sized at 2 inches diameter. Bed depth will depend on the manner in which the limestone packs. A uniformly crushed limestone of 2 inches diameter can be deposited to about a 6 inch depth. The flame will penetrate. A non-uniformly crushed material of slabby nature cannot be deposited as deeply because the flame cannot penetrate as well. Flame penetration is the limiting factor.

It will be understood that the optimum efficiency and quality of calcination will occur when all the pieces of limestone are of exactly the same size and shape when the bed depth is the same over the complete hearth area; in that such perfect conditions make the sizing of burners, the determination of flame length, etc., more accurate. In actual practice such ideal conditions do not exist and irregular-shaped pieces of limestone of different sizes must be processed at the same time, and the bed depth will vary from point to point on the hearth. Coupled with this, all limestone, even from the same quarry, will not be of the same nature of uniform composition; therefore, the temperatures and heating rates will vary from kiln installation to kiln installation. However, this invention should greatly decrease the effect that these variations will have upon the quality of the individual pieces of limestone processed. Further, since a greater production can be achieved for a given kiln hearth area, fixed losses such as air infiltration to the chamber, radiation from the sidewalls, roof and hearth of the chamber, and radiation losses through openings remain constant and the overall fuel efficiency of the kiln is improved.

This process and apparatus enables me to subject the limestone charge to the direct flame of the heating source, thereby permitting the use of a greater depth of limestone bed than hitherto employed, while at the same time creating a higher temperature environment for the limestone charge without increasing the temperature of the calcining chamber. The invention provides a means for quickly removing the CO₂ of disassociation as well as other gaseous contaminants from the limestone bed, which in turn also increases the temperature environment of the limestone pieces. In this process one is readily able to control the heat input in like proportion to the heat demand for calcining and simultaneously provide means for controlling the flow of spent products of combustion and gas of disassociation within the heating chamber. I am also enabled to achieve underburning or overburning of the limestone pieces without affecting the increased productivity.

What I claim as my invention is:

1. A continuous method of calcining limestone in a chamber having refractory walls, spaced apart fuel burners and a refractory hearth movable through said chamber comprising the steps of depositing limestone pieces in a layer on the hearth, heating the limestone pieces to calcining temperature by moving the hearth through a series of spaced burner zones in said chamber and by directing burning gases from said fuel burners through the surface of the layer and downwardly into the layer to burn around the limestone pieces and against the hearth, evacuating CO₂ and other gases released from the limestone and gas combustion from said chamber and removing the limestone pieces from the hearth.

2. A continuous method of calcining limestone in a chamber having refractory walls, spaced apart fuel burners and a refractory hearth movable through said chamber as claimed in claim 1, wherein a different portion of the transverse extent of the surface of said layer of limestone in adjacent burner zone is free from impinging burning gases from said fuel burners at any given time whereby to assist the free escape of CO₂ and other gases released from the limestone and gas combustion.