APPARATUS FOR AND METHOD OF CONTROLLING ROTARY KILN OPERATION

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Filed: May 1, 1970
Appl. No.: 33,811

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ABSTRACT

An apparatus for and method of controlling the operation of a cement kiln or the like in accordance with which means are provided for determining the temperature at two axially spaced locations within the calcining zone of the kiln, determining the differential between the temperatures measured at the two axially spaced locations as an indication of whether or not the burning zone of the kiln is located at a desired axial location within the kiln, and making proper control adjustment or adjustments to the kiln to maintain substantially constant the predetermined differential between the two measured temperatures, whereby to maintain the burning zone at the proper axial location within the kiln.

6 Claims, 3 Drawing Figures
Fig. 2

Fig. 3

Fig. 4

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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for and method of controlling the operation of a cement kiln or the like.

2. Description of the Prior Art

A typical cement manufacturing installation, for example, comprises an inclined rotary kiln having its lower discharge end enclosed within a firing hood. A heat source or kiln burner extending through the firing hood, utilizing fuel and primary combustion air, fires the kiln from the discharge end of the kiln. A clincker cooler conveying a perforated grate and a wind box beneath the grate extends underneath the firing hood so that its receiving end is below the discharge end of the kiln.

A finely ground mixture comprising a natural carrier of CaCO₃ such as limestone, natural carriers of SiO₂ and Al₂O₃ such as clay or shale, and Fe₂O₃ in the form of hematite or mill scale, is introduced in the form of a dry raw mix or a wet slurry into the elevated end of the kiln and due to the kiln's rotation and incline, it is transported toward the discharge end. Flame from the kiln burner is introduced into the discharge end of the kiln and this flame and its hot combustion byproducts are drawn through the kiln countercurrent to the flow of the charge therein, heating the charge in the process. As the charge progresses, its temperature is first raised to a level which drives off moisture. Then it progresses to a hotter general area in the kiln known as the calcining zone where temperatures are sufficient to dissociate the CaCO₃ (limestone) into CaO and CO₂. It then progresses to the hottest zone or burning zone where CaO combines with SiO₂ to form cement clinker.

The chemical reactions taking place in the kiln, especially in the calcining zone, are complex and critical and determine the quality of the cement produced. It is important that the reactions taking place in the calcining zone, namely, the endothermic dissociation of CaCO₃ into CaO and CO₂ be carried to completion before the material is elevated to the temperature where the exothermic combination of SiO₂ and CaO occur. Otherwise, residual traces of CaCO₃, would then endothermically dissociate causing localized cooling and preventing some of the CaO and SiO₂ from reaching the critical reaction temperature necessary for their combination. This would result in a residuum of incompletely combined particles of calcium and silica, the presents of free lime, etc. Since the calcium-silica reaction is exothermic, it will be realized that clinker resulting from complete calcination and burning will be hotter than clinker wherein the reaction was not completed. Properly burned clinker will also generally be more dense than improperly burned clinker.

In a typical cement kiln which might be, for example, 400 feet in length from the feed end to the discharge end thereof, the heating zone in which moisture is driven off from the mixture might extend, for example, for approximately 250 feet from the feed end in the direction of the discharge end; the calcining zone might extend for an additional 75 feet from the termination of the heating zone to the beginning of the burning zone; and the burning zone might extend for the last 75 feet of the length of the kiln from the end of the calcining zone to the discharge end of the kiln. The values just given are only examples of the lengths of the various zones in a typical kiln.

While the lengths of the various zones within the kiln may vary from one kiln to another, in a given kiln, assuming a given end produce produced and a given fuel used, the locations and lengths of the burning zone, the calcining zone, and the heating zone remain fixed for optimum operation of the given kiln. Thus, for example, if a given kiln has a burning zone which is 75 feet in length starting at the discharge end of the kiln and extending toward the feed end of the kiln, for optimum operation of the kiln the 75 foot length burning zone should remain fixed in the given kiln, assuming the kiln end product and fuel used remain unchanged. However, the problem arises that during operation of a kiln due to various operating conditions which arise, there may be a tendency for the length of the burning zone particularly to change from its optimum length and position with resulting reduction in the efficiency of operation of the kiln.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an apparatus for and method of controlling the position of the burning zone of a rotary cement kiln or the like to insure optimum operation of the kiln.

It is another object of the invention to provide an apparatus for and method of controlling the operation of a cement kiln or the like to provide optimum efficiency in the operation of the kiln.

In achievement of these objectives, there is provided in accordance with this invention, an apparatus for and method of controlling the operation of a cement kiln or the like in accordance with which means are provided for determining the temperature at two axially spaced locations within the calcining zone of the kiln, determining the differential between the temperatures measured at the two axially spaced locations as an indication of whether or not the burning zone of the kiln is located at a desired axial location within the kiln, and making proper control adjustment or adjustments to the kiln to maintain substantially constant the predetermined differential between the two measured temperatures, whereby to maintain the burning zone at the proper axial location within the kiln.

Further objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawing in which:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view in longitudinal elevation of a rotary kiln embodying the apparatus of the invention;

FIG. 2 is a diagrammatic representation of the various zones within the kiln; and

FIG. 3 is a graph of the "under the load" temperature of the cement mixture in the kiln versus kiln length.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, and more particularly to FIG. 1, there is shown a rotary kiln generally indicated at 10 comprising a cylindrical kiln shell 12. The kiln 10 is supported for rotation on its foundation 14 which is so constructed as to impart a slight downward inclination to the kiln from the feed end to the discharge end of the kiln. Rollers 16 mounted on foundation 14 cooperatively engage riding rings 18 mounted on the kiln shell 12 in any well known manner for rotation of the shell about the longitudinal axis of the kiln. Appropriate driving means (not shown) may actuate a bevel gear 26 carried by kiln shell 12 for revolving the kiln. The lower end of the kiln is associated with a firing system 28 which may be either a coal, gas-burning or other suitable type for furnishing hot gases. The material to be heated in the kiln is supplied to the feed end of the kiln by means of a chute or hopper 32. As indicated in FIG. 2, in kiln 10 which is assumed to be 400 feet in length, the heating zone of the kiln extends for a predetermined distance such as 250 feet from the feed end of the kiln; the calcining zone in the given kiln may extend for the next 75 feet proceeding toward the discharge end; while the burning zone may extend for 75 feet from the end of the calcining zone to the discharge end of the kiln. These values are given merely by way of example and shall in no way be limiting. However, in a given kiln, the lengths and positions of the various zones remain fixed for optimum operation of the kiln.

The present invention relates to a means and method for insuring that the burning zone in a given kiln remains at its predetermined optimum length and position.
In accordance with the invention, a pair of temperature sensing devices, preferably radiation pyrometers indicated at 34 and 36, are positioned at two spaced points or locations along the kiln to measure a temperature differential between the two spaced points, corresponding to points A and B on the temperature curve of FIG. 3. The two points A and B are so located within the calcining zone that the temperature vs. kiln length curve (FIG. 3) should have a predetermined slope between points A and B, as indicated by a predetermined temperature differential between points A and B, if the burning zone is optimized for operation of the kiln. Points A and B are selected so as to lie at points on the temperature curve of FIG. 3 at which an upward break in the rate of temperature climb vs. kiln length occurs, assuming optimum operation of the kiln and proper location of the burning zone. The radiation pyrometers 34 and 36 may be similar to those shown in U.S. Pat. No. 3,345,873 issued to Otto G. Lel- lep on Oct. 10, 1967; or in U.S. Pat. No. 3,379,062 issued to Otto G. Lellep on Apr. 23, 1968; or in U.S. Pat. No. 3,472,497 issued to Harold D. Preszler on Oct. 14, 1969; or in U.S. Pat. No. 3,473,384 issued to Anthony V. Baron on Oct. 21, 1969. The radiation pyrometers shown in the patents just mentioned are mounted on the outside of the kiln and receive radiation from the kiln interior through a sight tube or passage which extends through the kiln wall. The two temperature sensing devices 34 and 36 are located in axially spaced locations along the calcining zone of the kiln. For example, if in a 400 foot kiln, the feed end of the kiln is considered to be the zero foot mark, with the optimum location of the calcining zone extending from the 250 foot mark to the 325 foot mark, and with the optimum location of the burning zone extending from the 235 foot mark to the 400 foot mark, the first radiation pyrometer device 34 may be installed, for example, at the 275 foot mark fifty feet upstream from the junction of the burning zone and calcining zone, and the second radiation pyrometer device 36 may be installed at the 285 foot mark, 40 feet upstream from the junction of the calcining zone with the burning zone. Thus, in the typical example just mentioned, the two radiation pyrometer devices 34 and 36 are spaced from each other 10 feet lengthwise of the kiln axis, and both of the pyrometer devices 34 and 36 are located within the normal location of the calcining zone.

The radiation pyrometer device 34 feeds its signal to slip rings 40 and 42 mounted on the kiln; while the radiation pyrometer 36 feeds its output signal to the slip rings 44 and 46. Contact brushes 48 connect slip rings 40 and 42 from radiation pyrometer 34 to the input of a suitable electrical amplifier 50. Similarly, contact brushes 52 connect slip rings 44 and 46 from radiation pyrometer 36 to the input of an electrical amplifier 54.

The slip rings 40-42 and 44-46 may extend around the outer periphery of the drum only for an angle or arc approximately corresponding to the arc subtended by the load in the kiln and the brushes 48 and 52 may be so positioned that they contact their corresponding slip rings only during the portion of the cycle of rotation during which the respective radiation pyrometers 34 and 36 are passing "under the load" in the kiln. Thus, the temperature signals transmitted to the amplifiers 50 and 54 will be readings of the "under the load" temperature at each of the respective locations A and B, which is the best criterion of material temperature in the kiln at these respective locations.

The electrical output signals from the amplifiers 50 and 54 are fed into the input of a signal subtracting device or differential amplifier 56 which provides an electrical output signal indicative of the differential between the two temperature signals from the radiation pyrometer temperature detecting devices 34 and 36. The differential amplifier 56 may be, for example, an operational amplifier connected in subtractive relation such as Philbrick Model SP-456, listed on page 534 of the 1068-69 Electronic Engineer's Master Catalog, published by United Technical Publications, 645 Stewart Avenue, Garden City, New York. Other devices suitable for use as differential amplifier 56 are also well known and commercially available. The signal from the differential device 56 is fed to any suitable control device 58. If the firing zone of the kiln is properly located at its optimum position in the kiln, a predetermined temperature differential signal will be produced by the differential or differential device 56, and this signal is at the proper predetermined value no adjustments to the kiln operation will be made. However, if the output signal from the differential device 56 is different than the predetermined value which corresponds to the proper location of the firing zone in the kiln, then the signal fed from the differential device 56 to the control 58 will provide suitable adjustments to cause the firing zone to return to its proper location. Such adjustments may include, for example, any one of or combination of the following control adjustments of kiln operating variables: (1) a change in the fuel rate to the kiln; (2) a change in the rate of kiln rotation; (3) a change in the fuel rate to the burner or firing means which supplies heat to the kiln; (4) a change in the axial position of the burner or firing means; or (5) a change in the draft through the kiln.

While there has been shown and described a particular embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and, therefore, is aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In combination, a rotary kiln for processing cement or the like, said kiln including therein a heating zone, a calcining zone, and a burning zone, each of said zones having a predetermined location in said kiln corresponding to optimum operation of said kiln, temperature sensing means for sensing the temperature in said kiln at two axially spaced locations in the calcining zone of said kiln whose temperature differential is indicative of the location of the burning zone in said kiln; said two axially spaced locations being so positioned as to lie in a region of said calcining zone at which an upward break in the rate of temperature climb vs. kiln length occurs, assuming optimum operation of the kiln and proper location of the burning zone, a differential measuring means, means connecting said temperature sensing means to said differential measuring means whereby to provide an output signal from said differential measuring means which is a function of the temperature differential between said two axially spaced locations, control means for controlling the operation of said kiln in response to the output signal of said differential measuring means, and means connecting the output signal of said differential measuring means to said control means whereby to control the location of said burning zone.

2. The combination defined in claim 1 including a separate temperature sensing device positioned at each of said two axially spaced locations, and means connecting each temperature sensing device to said differential measuring means.

3. The combination defined in claim 2 in which each temperature sensing device is a radiation pyrometer.

4. A method of controlling cement kiln operation comprising the steps of determining the temperature at two axially spaced locations in the kiln, determining the temperature differential between said two locations as indicative of whether or not the burning zone is located at a desired optimum axial location within the kiln, and controlling at least one kiln operating variable to maintain substantially constant a temperature differential between said two locations corresponding to the location of the burning zone at said desired optimum location.

5. A method as defined in claim 4 in which the temperature is measured "under the load" at each of said two axially spaced locations.

6. A method as described in claim 4 in which the temperature is measured "under the load" at each of said two axially spaced locations.