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Hofer et al.

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[54] **METHOD FOR CARRYING OUT ENDOTHERMIC PROCESSES IN A SHAFT FURNACE**

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[52] **U.S. Cl.** **432/14**

[51] **Int. Cl.** **F27b 9/02**

[58] **Field of Search** ..... 263/17, 29, 30, 53 R; 432/14

[56] **References Cited**

UNITED STATES PATENTS

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[57] **ABSTRACT**

A process for calcining lime in a furnace or kiln having two spaced vertical shafts including each a preheating, a combustion and a cooling zone and joined together at the lower end of the combustion zone, comprising heating the material in the preheating zone, introducing a current of primary air into the top of one shaft to flow through the combustion zone into the other shaft upwardly and outwardly together with waste gas, introducing secondary air into one or both shafts in a counter flow direction from the bottom of the cooling zone, and feeding a fuel material into the combustion zone at more than one position so that a portion of the fuel material burns only with the secondary air.

6 Claims, 4 Drawing Figures

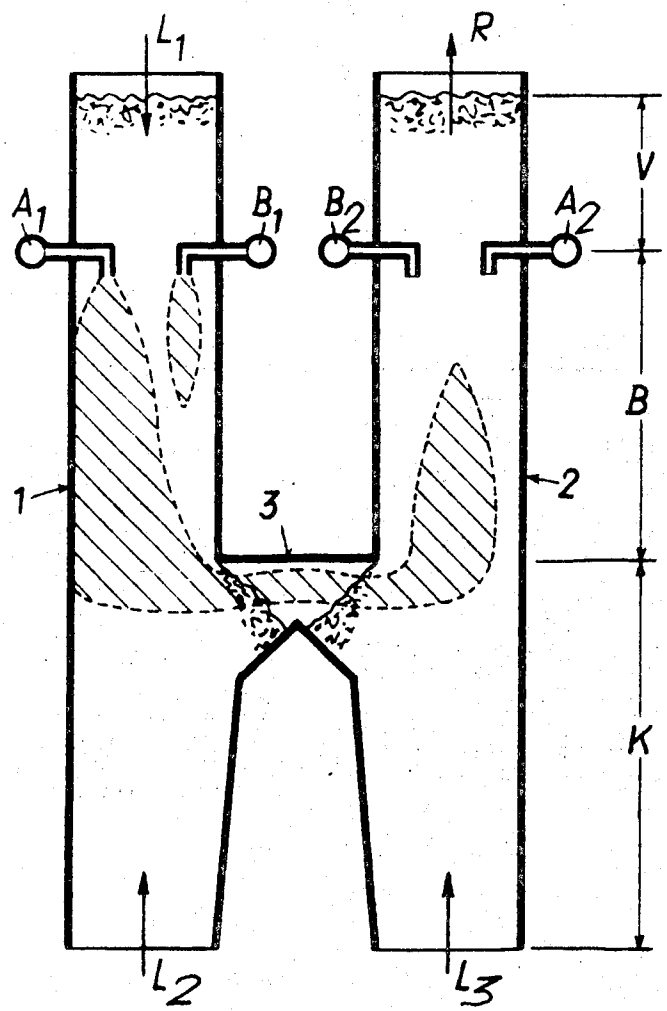


FIG. 1

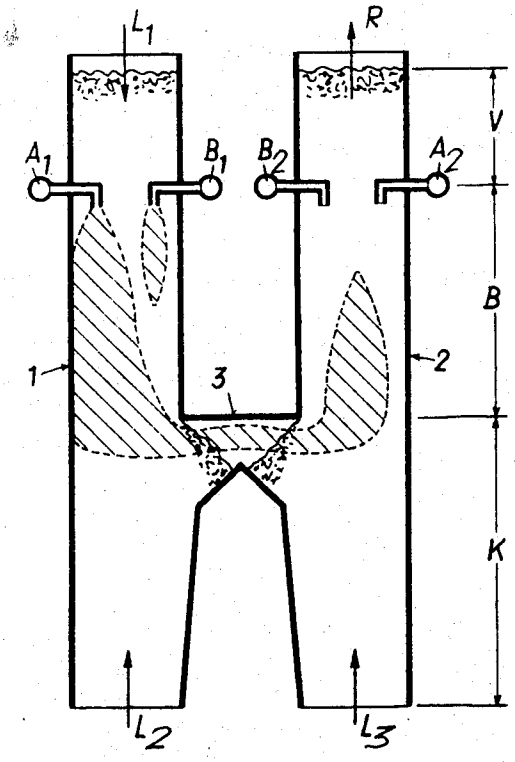


FIG. 2

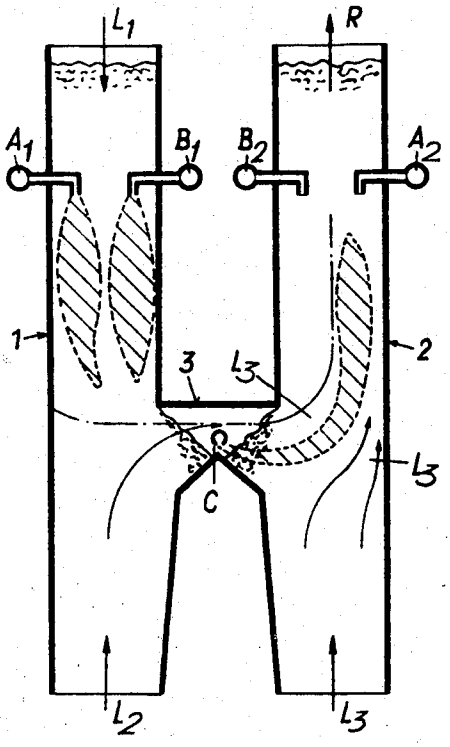


FIG. 4

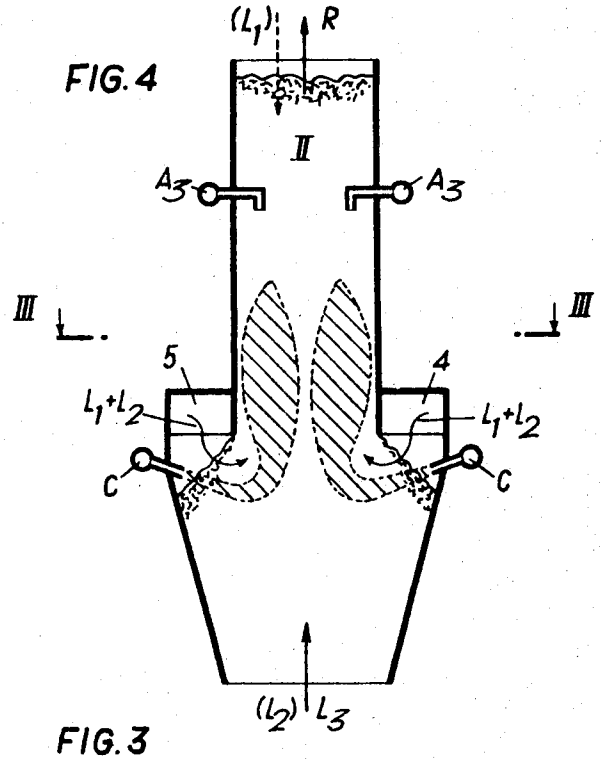
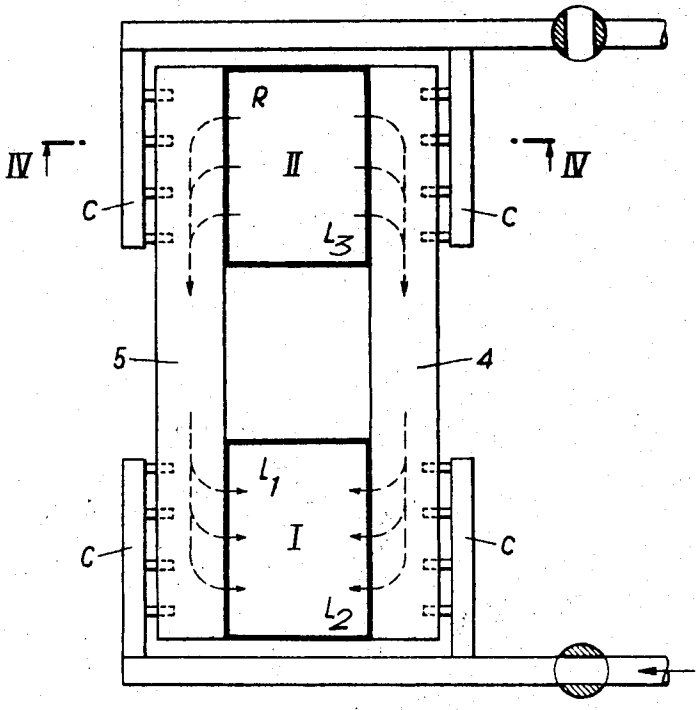

(L1)
R
II
A3
A3
III
III
5
4
L1+L2
L1+L2
C
C
(L2)
L3

FIG. 3


R
II
IV
IV
C
C
L3
5
4
L1
I
C
C
L2

METHOD FOR CARRYING OUT ENDOTHERMIC PROCESSES IN A SHAFT FURNACE

This invention relates to endothermic processes in a shaft furnace or kiln. More particularly it relates to a process for calcining lime, in which the material being calcined is preheated in a first zone, is subjected in a subsequent combustion zone to the direct action of a fuel and then in a third zone subjected to cooling. According to a special feature of this method the preheating zone is traversed at least by a part of the heat carrier required for the calcining process alternately with flow in the same direction or direct flow and then in the opposite direction or counter-flow, so that the excess heat occurring in a conventional shaft furnace or kiln can be utilized again in the preheating zone for the calcining process.

In practice the known method is essentially conducted with two furnace or kiln shafts which are joined to each other at the lower end of the combustion zone by a connecting dust, fresh air for combustion (primary air) being admitted during the first combustion period in one of the shafts through an opening above the preheating zone and is then directed outwards in a direct flow through the combustion zone and subsequently through the connecting duct into the second shaft in which it flows upwards in a counterflow with the waste gas produced. Secondary or cooling air is fed into one or both shafts in a counter-flow from the bottom of the cooling zone and it joins with the primary air. These operations are repeated by changing over into a second combustion period.

In practice furnaces have been so operated hitherto that the primary air was utilized almost exclusively for the combustion of the fuel and the secondary cooling air only had a carrier furnace for transferring the heat of the lime into the preheating zone. Thus excessively high temperatures in transfer or by-pass apertures between the two shafts made it impossible to feed in the direct flow shaft more fuel than that which corresponded to the primary air. The utilization of cooling air from the combustion of fuel would provide better economy of the furnace, because greater efficiency could be achieved with the same resistance to flow. The present invention therefore has the aim of not only utilizing cooling air for cooling the calcined lime but also for the combustion of fuel. In accordance with the present invention a process is provided in which the fuel is fed to the material being calcined at more than one place to a varying degree and in such a way that a part of the fuel burns only with the cooling air fed to the shaft or shafts from the bottom.

According to one aspect of the invention the fuel gas is supplied at two positions at the top of the combustion zone, the fuel-air ratio, λ, at one position being above 1.0 and below 1.0 at the other position.

According to another aspect of the invention fuel gas is also supplied in the connecting duct between the two shafts in addition to being supplied at the top of the combustion zone.

According to a third embodiment of the invention, in a twin-shaft furnace or kiln having transfer ducts between the two shafts, enough fuel is fed into the particular direct flow shaft so that combustion is terminated in this direct flow shaft, further fuel is then fed in the particular counter-flow shaft in the region of the banks of the material being calcined below the transfer ducts between the two shafts. The fuel then burns with the cooling air fed from the bottom of this counter-flow shaft or with the residual air from the direct flow shaft.

These embodiments of the invention will now be explained in more detail in the following description with reference to the drawings, in which:

FIG. 1 represents a double-shaft furnace or kiln in which the fuel is fed at two different positions at the top of the combustion zone in unequal amounts,

FIG. 2 shows a double-shaft furnace or kiln of substantially similar design to that of FIG. 1, however, fuel is supplied in the connecting duct between the two shafts as well as at the beginning of the combustion zone,

FIG. 3 shows a double-shaft furnace or kiln which has shafts connected by lateral transfer or by-pass ducts,

FIG. 4 is a section along the line IV—IV in FIG. 3.

Reference is now made to FIG. 1 which shows a double-shaft furnace or kiln, such as is disclosed in British Pat. Specification No. 896,460 (FIG. 2) and consists of shafts 1 and 2 which are connected to each other by a connecting duct 3. The material to be calcined is introduced into the shafts 1, 2 at the top and undergoes preheating in a zone V, in zone B it is calcined and in zone K it is subjected to the action of the cooling air flowing in at the bottom. Subsequently the calcined material is removed at the bottom. The fuel is fed to the material being calcined at the beginning of the combustion zone through two rows of nozzles A_1, B_1 in the form of fuel gas, however, the row of nozzles A_1 is supplied with more fuel than is required by the proportion of combustion air L_1 flowing through the associated outer region of the shaft. Accordingly at the lower end of the combustion zone B fuel gas remains and burns with the residual air left over from the inside region of the shaft and with the cooling air L_2 which enters from the bottom. The residual air at the inside region of the shaft originates from the combustion air L_1, and remains since less fuel gas has been supplied to the row of nozzles B_1 than that required by the volume of combustion air flowing through the shaft in the region of this row of nozzles. The volume of fuel gas still present after flowing over into the second shaft then burns with the cooling air which is substantially in counter-flow. The gases rising through the preheating zone preheat the material being calcined which is descending in this shaft.

The fuel-air ratio, λ, is for example 1.3 at the nozzle rows A_1, A_2 and approximately 0.6 at the nozzle rows B_1, B_2.

After changing over the furnace or kiln to the next combustion period fuel gas is then supplied through the nozzle rows B_2 and A_2 with the surplus fuel gas originating from the nozzle row A_2 burns with the cooling air L_3 fed into this shaft from the bottom.

If it is desired to calcine the lime more severely fuel is fed not only through the nozzle rows A_1 and B_1 (and A_2, B_2, respectively) but also into the connecting duct at C. Here cooling air L_2 and L_3 is fed to the two shafts at the bottom. At the point C the fuel gas is supplied in such a way that it enters downwards into the banked material being calcined, the cooling air L_2 flowing above and the cooling air L_3 flowing below the fuel gas in the particular counter-flow shaft as shown in FIG. 2. Accordingly the fuel burns between the two cooling air streams L_2 and L_3.

In this case the fuel is supplied at the rows of nozzles A_1, B_1 (A_2, B_2) in such a way that the lime is calcined uniformly over the entire shaft cross-section with direct flow. Thus enough fuel is supplied so that it cannot burn completely in the direct flow shaft, but only burns in the counter-flow shaft after combining with the cooling air L_3. It is advantageous to make the volume of cooling air L_2 larger than the volume of cooling air L_3.

Another aspect of the invention utilizes a double-shaft furnace whose shafts are not connected directly by means of a duct but are connected to each other by lateral transfer or by-pass ducts.

FIGS. 3 and 4 illustrate a double-shaft furnace or kiln in which are arranged at the beginning of the combustion zone two rows of nozzles A_3. Nozzle rows C are provided above the lateral conical banks of the bulk material. The required cooling air L_2 or L_3 flows from the bottom into the calcined material.

In such furnaces or kilns it is preferred that any combustion of the fuel occurs in the transfer ducts **4** and **5**. Therefore enough fuel gas is supplied through the nozzle rows A that combustion is completed in the respective direct flow shaft and only hot residual gas flows over through the transfer ducts **4** and **5** into the second shaft and passes upwards in this shaft through the material being calcined. In this way overheating of the ducts **4** and **5** and the formation of deposits from sintered dust in the ducts is prevented. At the point C fuel is then blown on to the banks below the connecting ducts. The temperature of the flame produced depends on the oxygen content of the residual gases flowing through the ducts. Thus in the direct flow shaft the fuel gas supplied at the nozzle rows A_3 burns with the air L_1 fed in at the top. How much oxygen from the air L_1 is left for the combustion of the fuel admitted at points C, depends on the surplus of air. Cooling air L_2 and L_3 can now be distributed as desired to the direct and counter-flow shafts. When more cooling air is supplied in the direct flow shaft, the gases fed through the transfer ducts become richer in oxygen. In this way it is possible to control the flame temperature and consequently the soft burned quality of the lime.

A shaft furnace or kiln working in accordance with the method of the invention requires for example 900 Kcal/Kg of lime. The cooling air requirement in this case is 0.65 Nm^3/Kg of lime. In the case of natural gas with a lower calorific value of 9,000 Kcal/Nm^3 the gas requirement per Kg of lime is 0.1 Nm^3/Kg. The theoretical air requirement for complete combustion is $1.06.900/1{,}000 = 0.95$ Nm^3 air/Kg lime.

In the case of the kiln according to FIG. **1**, 80 percent of the combustion air is supplied as L_1, i.e., $0.8.\ 0.95 = 0.76$ Nm^3/Kg. 35 percent of the fuel gas arrives through the row of nozzles B_1, therefore $0.35.\ 0.1 = 0.035$ Nm^3/Kg, and the rest of the fuel gas (0.065 Nm^3/Kg) is supplied through the row of nozzles A_1 into the kiln.

Experience has shown that the mixing of gases in loose or bulk material is very poor so that it may be assumed that the surplus of air at B_1 is hardly utilised for burning the gas from A_1 in the first shaft. Accordingly only some of the gas from A_1 is burned up, usually this is 40 percent of the total gas. Of the 0.065 Nm^3/Kg is burned therefore 0.04 Nm^3/Kg.

0.025 Nm^3, that is 25 percent of the total fuel, arrives in the shaft **2** and burns there with the 0.65 Nm^3 of cooling air which flows in as L_2 and L_3. The 0.035 Nm^3 of gas which flows in at B_1, burns up completely since in the right shaft half the combustion air is present for 0.04 Nm^3 of gas.

In the case of the kiln according to FIG. **2** 80 percent of the combustion air or 0.76 Nm^3 is supplied as L_1. The distribution of combustion is as follows:

at A_1	35%	0.035 Nm^3/Kg,
at B_1	40%	0.04 Nm^3/Kg,
at C	25%	0.025 Nm^3/Kg,

Fuel gas from A_1 burns without residue in the first shaft. Fuel gas from B_1 burns almost completely in the first shaft; there is a slight residual combustion in the dust and in the second shaft after combining with the cooling air L_2. C burns in the second shaft between the cooling air L_2 and L_3.

The two rows of burners in the shaft II of the kiln or furnace according to FIG. **3** are each supplied with 35 percent of the fuel gas. The two rows of burners C in the shaft I, however, are each supplied with 15 percent of the fuel gas.

The overgrate blast L_1 amounts again to 80 percent, (0.76 Nm^3/Kg). The fuel gas entering at A_3 burns up completely in the shaft II. The waste gases thus produced mix with the cooling air L_3 (0.325 Nm^3/Kg) and pass over into the shaft I via the ducts **4** and **5**. The fuel gas entering at C in shaft I burns in two flames between the waste gas now containing oxygen and the cooling air L_2 (0.325 Nm^3/Kg).

We claim:

1. A process for an endothermic reaction in a furnace or kiln having first and second vertical shafts with each shaft having, from top to bottom, a preheating zone, a combustion zone and a cooling zone, means for joining the two shafts and providing communication therebetween at the lower regions of the combustion zones and fuel gas supply means located in each shaft and in the means for joining the shafts, which process comprises:

a. Introducing the materials required to undergo the reaction down into the tops of the shafts,

b. preheating the materials in the preheating zones of the shafts,

c. introducing a source of primary air down into the top of the first shaft concurrently with the materials being fed therein,

d. feeding fuel gas into the combustion zone of the first shaft from the fuel gas supply means located therein such that a portion of the fuel gas is caused to enter into the second shaft through the means joining the two shafts,

e. introducing a source of secondary air up into the bottom of at least the second shaft countercurrently against the materials being fed therein such that only the secondary air effects combustion of the portion of the fuel gas entering the second shaft.

2. The process according to claim **1** wherein the steps of the process are reversed in alternate cycles with respect to the first and second shafts.

3. The process according to claim **1** wherein the fuel gas is fed into the combustion zone of the first shaft from two positions located at the upper region of the combustion zone.

4. The process according to claim **3** wherein the fuel to primary air ratios at the two positions are above 1.0 for one position and below 1.0 for the other position.

5. The process according to claim 1 further including supplying fuel gas into the means for joining the shafts from the fuel gas supply means located therein.

6. The process of claim 1 wherein the means joining the two shafts together includes at least two by-pass ducts for effecting lateral transfer of gases between the two shafts.

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